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CENTRAL RICE RESEARCH INSTITUTE, CUTTACK

ANNUAL REPORT FOR THE YEAR 1955-56

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Season & crop conditions.—The total precipitation during the year was 75·13″ as against the normal annual rainfall of 61·30″, but the distribution of the rains was rather erratic. In the months of July and August, the crop suffered from want of adequate rains, while during the last week of August and the first week of September there was 13·74″ of rainfall, causing floods and during the months of October and November also there was heavy precipitation far in excess of the normal. The crop yields were in general adversely affected by the unfavourable weather conditions described above. The distribution of rainfall as compared to the mean of the decade, 1946-56, is given in Table I below :

TABLE I

Rainfall in inches in 1955-56 *as compared to the average of the last ten years*

Monsoon	Month	Normal rainfall in inches (Average of ten years 1946-47 to 1955-56)	Rainfall in 1955-56	Deviation from the mean
S. W. Monsoon	June	7·91	5·10	-2·81
	July	10·79	4·75	—6·04
	August	14·13	13·53	—0·60
	September	11·31	19·88	+8·57
	TOTAL	44·14	43·26	—0·88
Post-monsoon	October	8·52	19·40	+10·88
	November	2·86	6·33	+3·47
	TOTAL	11·38	25·73	+14·35
Winter	December	0·43	0·00	—0·43
	January	0·29	0·00	—0·29
	February	0·82	1·93	+1·11
	TOTAL	1·54	1·93	+0·39
Pre-monsoon	March	0·81	0·63	—0·18
	April	0·93	0·00	—0·93
	May	2·50	3·58	+1·08
	TOTAL	4·24	4·21	—0·03
	TOTAL FOR THE YEAR	61·30	75·13	+13.83

There was no severe outbreak of pests and diseases in the main crop season, but there was a moderate outbreak of 'blast' in the 2nd crop season.

AGRONOMY

I. *Varietal Trials*

The yield performance of 125 varieties, grouped according to their duration was tested in five varietal trials during the main crop season, and that of 42 varieties in the second crop season. Besides, 110 types were grown in observation plots to determine their suitability for the second crop season.

In 85-105 days trial, twenty varieties were tried against the local standard, *Benibhog*. Variety Ptb. 10 gave 40 per cent more yield than the standard, which gave 1533 lb. per acre. A. C. 2150 and B. 76-1 gave 15·1 and 11·6 per cent higher yield respectively than *Benibhog*, but the differences were not significant.

In 110-125 days duration trial repeated this year with twenty five varieties, with T. 635 as standard, five varieties, *viz*., Ch. 4, Ch. 58, T. 2058, MGL. 2 and Ptb. 13, yielded better than the standard which gave 1771 lb. per acre; but only Ptb. 13 was significantly superior to the standard in yield.

In 125-140 days duration trial, the standard, SLO. 6, yielded 2394 lb. per acre and as in previous years, the following varieties, T. 141-89, B.K. 6, T. 1879, SL. 202-*Kalamdani*, gave higher yields than the standard SLO. 6, but the differences were not significant. Of these, the variety T. 141-89, a selection from the popular improved variety T. 141, gave 6 per cent higher yield than its parental material T. 141. During the last season it gave 16·4 per cent better yield than T. 141.

In the 145-160 days duration trial, thirty varieties were tested with T. 1242 as the standard. Three varieties, HR. 35, MTU. 21 and BAM. 9, gave significantly higher yields than the standard, which yielded 2381 lb. per acre. This is the 4th year in succession in which BAM. 9 has given higher yield than the standard.

In the trial of varieties of over 170 days in duration, Co. 19 and H R. 39 yielded 33 per cent and 21 per cent respectively, significantly higher than T. 1242, which yielded only 1752 lb. per acre in this trial.

In the second crop season trials, the varieties, MTU.15, MTU. 9, Co. 21, Co. 20, BJ. 1, and AC. 2150 were on par with the standard, Ptb. 10, which gave 1574 lb. per acre. BJ. 1 is a variety selected by Mycologist as resistant to 'blast'. During the season, there was 'blast' outbreak, and BJ. 1 was observed to be completely free from infection.

II. Manurial Trials

Efficiency of nitrogenous fertilizers for rice.—The experiment was conducted as in the last two years to test the relative efficiency of eight forms of nitrogenous fertilizers. The fertilizers were applied at two levels, 20 and 40 lb.N.

per acre at the time of planting. The yields obtained with various nitrogenous fertilizers are given in Table II below:

TABLE II

Yield of rice in lb. per acre for various forms of nitrogenous fertilizers

Serial No.	Fertilizers	Levels of N.		Mean
		20 lb.	40 lb.	
1	Ammonium sulphate	2,230	2,721	2,475
2	Ammonium chloride	2,075	2,608	2,341
3	Ammonium phosphate	2,150	2,498	2,324
4	Urea	1,860	2,402	2,131
5	Ammonium nitrate	1,804	2,254	2,029
6	Ammonium sulphate nitrate	1,965	2,284	2,124
7	Calcium cyanamide	1,678	1,898	1,788
8	Sodium nitrate	1,616	1,742	1,679
9	Control	..	1,608	1,608
	Mean	1,922	2,301	

1. C.D. (·05) per acre for form means	138
2. C.D. (·05) per acre for level means	69
3. C.D. (·05) per acre for treatment means	199

As in the last two years, all the fertilizers except calcium cyanamide and sodium nitrate have given significantly high yield responses; the best responses, however, were obtained with ammonium sulphate, ammonium chloride and ammonium phosphate, between which there was no significant difference.

During the second crop season also, the above three fertilizers gave the best response in yield.

Placement and split application of ammonium sulphate for rice.—This experiment has been in progress since 1952-53 with a view to study the effect of placement of fertilizer in split doses at different stages of plant growth on

crop yield. It was repeated this season for the fourth year in succession with long duration, variety. T. 1242, under low lying conditions. The results obtained are presented in Table III below.

TABLE III

Yield of grain in lb. per acre under different placement and split application of Ammonium sulphate at 20 and 40 lb. N. per acre

Treatment		Nitrogen level lb. per acre		Mean
		20 lb. N/A	40 lb. N/A	
Time of application of fertilizers	1. Before planting	1,742	2,000	1,871
	2. At planting	1,822	1,998	1,910
	3. One month after planting	1,842	1,956	1,899
Method of application	1. Surface	1,756	1,953	1,854
	2. Sub-surface	1,916	2,217	2,066
Split doses	1. One dose	1,814	1,981	1,897
	2. Two doses	1,919	2,025	1,972
	3. Three doses	..	2,182	2,182
	Mean	1,830	2,039	

1. C.D. (·05) per acre for level means	56
2. C.D. (·05) per acre for individual means	175

The results obtained are in conformity with those of last year. Fractional application of the fertilizer again gave better yields than entire quantity applied in one dose, and the highest response was obtained, as before, with sub-surface application of fertilizer in three doses, *i.e.*, ½ at planting, ¼ one month after and ¼ one month before flowering to give in all 40 lb. N per acre.

Placement of different forms of nitrogenous fertilizers.—The effect of placement with four different types of nitrogenous fertilizers, *viz.*, ammonium sulphate, ammonium chloride, ammonium phosphate and urea on the yield of the

crop was compared in another experiment with the variety BAM. 9. The yield responses obtained with the different treatments are presented in Table IV below:

TABLE IV

Yield of grain in lb. per acre

[Variety : BAM. 9]

Fertilizers	Surface		Sub-surface			Mean
	At planting	One month after planting	Dry	At planting	One month after planting	
1. Control						2,181
2. Ammonium sulphate	2,686	2,525	2,639	2,670	2,695	2,641
3. Ammonium phosphate	2,495	2,478	2,423	2,567	2,506	2,494
4. Ammonium chloride	2,611	2,381	2,614	2,548	2,625	2,556
5. Urea	2,489	2,406	2,461	2,659	2,661	2,535
Mean	2,570	2,448	2,534	2,611	2,622	
	2,509			2,589		

1. C.D. (·05) per acre to compare form means	141
2. C.D. (·05) per acre to compare methods of application means	157
3. C.D. (·05) per acre to compare individual means	314

It might be seen from the above table that all the fertilizers have given significant increase in yield over the control. Urea which had given low response in previous year has given response comparable to that of ammonium sulphate during this year. This needs to be further tested. As in the other experiments, placement of fertilizer has given higher yields than the customary surface method, though the differences were not significant.

Long range manurial experiments.—These experiments, as previously reported are designed to investigate the cumulative effect of continuous application of various fertilizers and manures on the condition and productivity of rice soil.

(*i*) *Ammonium sulphate with and without lime and compost.*—This experiment has been in progress for the last eight years to study whether the continuous application of ammonium sulphate in varying doses has any deleterious effect on the soil productivity; and if so, whether it can be counteracted by the application of organic matter like compost and a soil ameliorant like lime. Ammonium sulphate at 0, 20 and 40 lb. N per acre is being applied every year on the same plots with and without 100 mds. of compost as the basal

dressing. Lime is applied once in three years, at 0, 4 and 8 cwt. per acre. The results are presented in Table V (a) & V (b) below:

TABLE V(*a*)

Yield of grain in lb. per acre.

[Variety : T. 1145]

Basal dressing of lime in cwt. per acre	No compost				Compost at 100 mds/A				Mean
	Top dressing of Ammonium sulphate Nitrogen lb./A								
	N_0	N_{20}	N_{40}	Mean	N_0	N_{20}	N_{40}	Mean	
L_0	1,608	2,046	2,224	1,926	2,005	2,294	2,292	2,197	2,061
L_4	1,507	1,923	2,191	1,874	2,059	2,422	2,282	2,254	2,064
L_8	1,453	2,000	2,302	1,918	1,991	2,417	2,271	2,226	2,072
Mean	1,489	1,989	2,239		2,018	2,378	2,281		2,065

TABLE V (*b*)

Nitrogen	Compost		Mean
	C_0	C_{100}	
N_0	1,489	2,018	1,753
N_{20}	1,989	2,378	2,183
N_{40}	2,239	2,281	2,260
Mean	1,906	2,226	2,065

1. C.D. (·05) per acre to compare compost means 23
2. C.D. (·05) per acre to compare N and lime means 66
3. C.D. (·05) per acre to compare N means at the same level of compost . 94
4. C.D. (·05) per acre to compare compost means at the same level of N . 147

So far no deleterious effect has been found in the plots to which ammonium sulphate alone has been applied continuously. Lime application, either alone or in conjunction with N had no effect on yield of rice. As in previous years, the basal dressing of compost with a top dressing of 20 lb. of nitrogen as ammonium sulphate has given the best yields.

(*ii*) *Ammonium sulphate with and without compost.*—This experiment was conducted for the 7th year in succession on the same site. The results are given in Table VI below:

TABLE VI

Yield of grain in lb. per acre

[Variety: T. 1145]

Top dressing of Ammonium sulphate Nitrogen lb./A	Basal dressing of Compost in mds./A		Mean
	C_0	C_{100}	
N_0	1,653	2,144	1,898
N_{20}	2,085	2,374	2,229
N_{40}	2,296	2,108	2,202
N_{60}	2,251	1,634	1,943
N_{80}	1,956	1,338	1,647
Mean	2,048	1,920	..

1. C.D. (·05) per acre for comparing compost means 121
2. C.D. (·05) per acre for acre comparing N means 75
3. C.D. (·05) per acre for comparing N means at the same level of compost. 107
4. C.D. (·05) per acre for comparing compost means at the same level of N. 166

As in previous years, the effect of ammonium sulphate was significant and also its interaction with basal dressing of compost. During this year, compost application has given a high response of nearly 500 lb. per acre. In the case of ammonium sulphate applied alone there was a significant yield increase up to 40 lb. N/A, but when applied over a basal dressing of compost, the yield increased significantly only upto 20 lb. N/A.

The yield-nitrogen relationship can be represented by the quadratic curve as given by the equation:—

No compost $y = 1650{\cdot}07 + 565{\cdot}32x - 122{\cdot}07x^2$.

Compost $y = 2210{\cdot}47 + 125{\cdot}35x - 90{\cdot}12x^2$.

where y is the expected yield in lb. per acre and x the N level—the unit of N being 20 lb./A. From the yield—nitrogen quadratic function, the estimated maximum yield of 2254 lb. and 2305 lb. per acre were obtained with 14 and 46 lb. N per acre in the form of ammonium sulphate applied over compost and no compost respectively.

(*iii*) *N. P. K. Experiment.*—The experiment, now in the 7th year is designed to find a suitable combination of the major plant nutrients, N, P and K for rice and to estimate their comparative performance with the basal

dressings of organic manures. Previously, the fertilizers were applied a three levels to supply 0, 20 and 40 lb. of N, P_2O_5 and K_2O. During the last and current season, the fertilizer doses were modified. Ammonium sulphate was applied at 0, 40 and 80 lb. nitrogen per acre, super-phosphate at 0, 50 and 100 lb. P_2O_5 per acre and potassium sulphate at 0, 30 and 60 lb. of K_2O per acre. The basal dressings of organic manures were applied as in previous years to supply 20 lb. N per acre.

The yield data are presented in Table VII (a) & (b) below:

TABLE VII (*a*)

Yield of grain in lb. per acre

[Variety: T. 1145]

Top dressing of ammonium sulphate Nitrogen lb./A	Basal dressing of Organics, at 20 lb N/A				Mean
	No manure	Compost	Ground nut cake	Green manure	
N_0	1,902	2,143	2,150	2,144	2,085
N_{40}	2,198	2,090	1,839	2,002	2,032
N_{80}	1,784	1,581	1,289	1,337	1,498
Mean	1,961	1,938	1,759	1,828	

TABLE VII (*b*)

Levels of P	Levels of K			Mean
	K_0	K_{30}	K_{60}	
P_0	1,992	1,895	1,894	1,927
P_{50}	1,859	1,877	1,841	1,859
P_{100}	1,826	1,812	1,867	1,836
Mean	1,892	1,861	1,867	..

1. C.D. (·05) per acre for comparing means for organics 188
2. C.D. (·05) per acre for comparing N means 79
3. C.D. (·05) per acre for comparing N means at the same level of organics . 157
4. C.D. (·05) per acre for comparing organic means at the same level of N . 227

It was found, as in previous years, that neither phosphate nor potash had any effect on rice yield, whether applied alone or in combination with organic or inorganic N. Similarly, the differences due to organic manures were not significant and nitrogen application gave significant increase in yield up to 40 lb. N level.

III. Cultural Trials

Crop Sequence Experiment.—This experiment, which is in progress for the last two years to determine the possibility of growing different legumes and cash crops in sequence with main season rice crop, was repeated with twelve rotational treatments in three replications. Eight different crops, besides *dalua* or *boro* crop of rice were grown during the preceding winter season to determine their suitability for inclusion in the sequence of cropping with rice and to study their effect on the succeeding rice crops. The different crop sequences tried and yield obtained are presented in Table VIII (*a*) below :

TABLE VIII(*a*)

Yield of rice and different single season rotation crops

Serial No.	Rotational treatments	Yield in lb. per acre	
		Preceding subsidiary crop	Succeeding rice crop (Variety Ptb. 10)
1	Fallow/rice	..	2,282
2	Rice (Ptb. 10)/rice	1,567	1,984
3	Rice following green manuring with dhaincha/rice	2,075	2,246
4	Rice following green manuring with mung/rice	1,979	2,207
5	Mung for seed (Type No. 1)/rice	173	2,533
6	Mung for seed+pillipesara/rice	221	2,529
7	Gram (T. 87)/rice	707	2,430
8	Ground-nut (T. 685)/rice	1,569	2,566
9	Cotton (P. 216 F*)/rice	1,265	2,129
10	Wheat (NP–761)/rice	508	2,331
11	Linseed (R. R. 40)/rice	473	2,350
12	Mustard (P–77)/rice	83	2,572
	C.D. (·05) per acre for treatment means	..	199

*Seed Cotton

Double cropping of rice with green manuring to the second-season crop of rice gave quite encouraging results as is seen from the table given below :

TABLE VIII(*b*)

Double cropping of Rice (Yield of paddy in lb. per acre)

[Variety : Ptb. 10]

Serial No.	Rotational Treatments	Preceding subsidiary crop	Succeeding rice crop	Total yield
1	Fallow/rice	..	2,282	2,282
2	Rice/Rice	1,567	1,984	3,551
3	Rice following green manuring with dhaincha/rice	2,075	2,246	4,321
4	Rice following green manuring with mung/rice	1,979	2,207	4,186

Thus with the proper sequence of cropping a high yield of paddy can be obtained from the same land in a year, provided irrigation facilities are available.

Three crops of rice per year.—The possibility of growing three crops of rice in a year on the same land was explored. Periodical plantings of different varieties were carried out under irrigated conditions. Results obtained show that with an assured irrigation supply, the total yield of as much as 9011 lb. of paddy per acre can be obtained by adopting the following sequence of cropping with judicious manuring:—

(1) First crop of a short duration variety planted by about middle of March and harvested by first week of June.

(2) Second crop of medium duration variety (T. 1879) sown in main season from July—December.

(3) Third crop of short duration rice sown by middle of December and harvested in April.

The data are presented in Table IX below :

TABLE IX

Details of planting and harvesting time and yield of three rice crops in succession

Crops	Variety	Date of planting	Date of harvest	Yield in lbs./A	Duration of the variety
I	Ptb. 10	22-3-55	7-6-55	3,313	Early
II	T. 1879	2-8-55	30-11-55	3,214	Medium
III	Ptb. 10	2-2-56	22-4-56	2,484	Early
	TOTAL			9,011	

Due to unavoidable circumstances, the planting of the third crop was delayed by more than a month this year.

The data also showed that the first crop transplanted after April and the second crop after August gave very poor yield.

The results have confirmed the findings of the previous year.

Herbicides for weed control in rice fields.—The experiment was repeated to evaluate the comparative efficiency of various formulations of selective herbicides for control of weeds in rice fields. The treatments included four different herbicides at 2 lb. acid equivalent in 100 gallons of water, customary hand weeding, and inter-culturing with Japanese rotary weeder.

The herbicides were sprayed once six weeks after transplanting of crop. Interculturing with Japanese weeder was done thrice at fortnightly intervals and hand weeding was done twice.

The results obtained are given in Table X below:

TABLE X

Yield of grain in lb. per acre

[Variety T. 141.]

Serial No.	Treatments	Yield in lb.A.	Percentage over the control
1	Japanese-weeder	2,727	135·2
2	Hand-weeding	2,655	131·9
3	Agroxone-3	2,563	127·0
4	M.C.P.A.	2,537	125·7
5	Fernoxone	2,490	123·4
6	Phenoxylene-30	2,483	123·0
7	Shell 2, 4-D	2,421	120·0
8	Chloroxone	2390	118·5
9	Kathon M7	2,364	117·2
10	Cornox	2,352	116·6
11	Control (No weeding)	2,017	100·0
12	2, 4, 5-T	1,999	99·1
	C.D. (105) per acre for treatment means		337

Except 2, 4, 5-T, all the other treatments had given a significantly higher yield than control (no weeding). There was no significant difference between the other chemicals, hand weeding or Japanese weeder treatments. As in previous years, the yields obtained with M.C.P.A. group of chemicals were higher than those obtained with 2-4, D formulations.

Time of spraying herbicides.—To determine the optimum time of spraying herbicides, Phenoxylene-30 and Chloroxone were sprayed 2, 6 and 10 weeks after planting @ 2 lb. acid equivalent per acre. Spraying of chemicals 6 weeks and 2 weeks after transplanting gave an increase in yield as compared to the hand-weeding treatment. Delayed spraying, *i.e.*, 10 weeks after planting of the crop caused reduction in yield as is seen from the following table:

TABLE XI

Yield of grain in lb. per acre

[Variety T. 141]

Treatments	Week after planting			Mean
	2 weeks	6 weeks	10 weeks	
1. Chloroxone	2,839	2,850	2,462	2,717
2. Phenoxylene-30	2,932	2,963	2,511	2,802
3. Hand weeding	..	..	..	2,770
4. Control	..	..	..	2,514
Mean	2,885	2,906	2,486	..

C.D. (·05) per acre for comparing treatment means 178

Therefore 2-6 weeks after planting is the optimum time for spraying for effective control of the weeds.

Nursery treatment experiment.—In the second crop season different methods of raising seedlings, *viz.* wet and dry nursery, manured and unmanured seed beds covered with alkathene and uncovered seed beds were compared to study their effect upon the final yield of the crop. There was no significant difference between the treatments as far as the final yield was concerned.

IV. Cultural-cum-Manurial Trials

The merits of various operations recommended under the Japanese method of rice cultivation were tested in a 2^5 confounded experiment as per co-ordinated plan drawn by the Indian Council of Agricultural Research. The following five factor combinations were included in the trial :

Treatment	Japanese method	Local Method
1	2	3
(i) Seed rate . .	15 lb. per acre.	32 lb. per acre.
(ii) Seed bed preparation	(a) Raised seed bed 4′ wide and 3″ high. (b) Sifting of seed and dipping in brine solution.	Flat seed bed.

1	2	3
(iii) Nursery Manuring .	Application of 1 md. of compost and 1 lb. Ammonium sulphate for 100 sq. ft. of nursery. After sowing covering seed with 1/8″ layer of compost and 1/8″ layer of ash.	40 lb. of compost for 100 sq. ft. of nursery.
(iv) Method of planting and weeding.	Transplanting in straight lines at 10″x 10″ with 4 seedlings per hole and 3 intercultures with Japanese weeder.	Bulk transplanting 3-4 seedlings per hole and two hand-weedings.
(v) Field Manuring .	(a) Basal dressing at the rate of 2½ tons of compost and 6,000 lb. of green leaf. (b) Application of 100 lb. of Ammonium sulphate and 100 lb. of Superphosphate per acre at planting. (c) Application of 100 lb. of Ammonium sulphate and 100 lb. of Super-phosphate one month after planting.	Basal dressing of compost at 2½ tons per acre.

A medium duration variety, T. 141 was used and the crop condition was satisfactory.

Out of the five factors tested, only one factor, *i.e.*, field manuring, was found to be statistically significant. Field manuring according to Japanese method depressed the yield of the grain to the extent of 965 lb. per acre. Yield data are given in the table below :

TABLE XII

Yield of grain in lb. per acre

[Variety: T. 141]

Sl. No.	Treatments	Local Method	Japanese Method
1.	Seed-rate	2,265	2,264
2.	Seed-bed preparation	2,187	2,343
3.	Seed-bed manuring	2,163	2,367
4.	Transplanting and weeding	2,247	2,283
5.	Field manuring	2,747	1,782
	Mean .	2,322	2,208

V. Co-ordinated varietal trials

As a measure of co-ordination between the various Central Institutes, it has been decided to conduct trials simultaneously at different Institutes to test the results under different climatic and soil conditions. During the year, trials with N. P. wheat and linseed varieties were conducted at this Institute in co-operation with the Indian Agricultural Research Institute, New Delhi..

Out of ten N. P. wheat varieties, included in the trial, N.P. 797 was the best which yielded 842 lb. of grain A, but the results were not found to be statistically significant.

The yield performance of eight Rust-Resistant linseed varieties was also tested and R.R. 440 which gave 562 lb. of grain per acre was found to be the highest yielding variety.

VI. Trials of Green Manure Crops

Under the scheme for the improvement of green manure crops for rice, financed by the Indian Council of Agricultural Research, ninety nine green manure species were collected from India and abroad and thirty two species which appeared promising were studied in detail for production of green matter, suitability to different crop seasons, resistance to drought and water-logged conditions, seeding ability and nitrogen content.

As regards production of green matter, *dhaincha*, sunnhemp, *Sesbania sericea*, cowpeas, *mung*, *Aeschynomene americana*, *Phaseolus semierectus* and *Sesbania speciosa*, when sown during May-June provided sufficient quantity of green matter (about 6,000 lb. per acre) for the main season rice crop transplanted in July-August. For manuring of second season rice crop, transplanted in January, *mung*, *Crotalaria usaramoensis*, *Crotalaria brownei* and *Sesbania sericea* provided more than 4,000 lb. of green matter per acre when grown between November-January. *Sesbania speciosa* sown in the standing crop of rice in November gave abundant green matter (20,000 lb. of succulent matter per acre) for incorporation in the succeeding season.

The perennial shrub, *Gliricidia maculata*, planted on road sides three years ago, was found to give a yield of 25-30 lb. of leafy matter per shrub in the month of July, which could be used for the main season crop. Fresh shoots and foilage were put forth in considerable abundance after topping off the tender shoots and sufficient green matter also became available for incorporation for the second crop rice in January. Thus *Gliricidia* is a perennial source of green manure and is capable of giving two cuttings every year which can provide green matter both for main and second season rice crops.

Most of the green manure species tried were found to be drought resistant to a considerable extent while a few species like *Sesbania aculeata* (*dhaincha*), *S. sericea*, *Aeschynomene americana* and *Phaseolus semierectus* were resistant to water-logging commonly met with in low lying rice areas.

Aeschynomene americana, *Tephrosia candida*, *Crotalaria* species like *C. usaramoensis*, *C. brownei* and *C. striata* were found to be heavy seed yielders and were free from insect attack. Besides, *Crotalaria usaramoensis* and *C. brownei* were found to be rich in nitrogen content which was nearly double that of *dhaincha* or sunnhemp.

Investigations conducted with a view to determine the optimum age and time of burying in *dhaincha*, showed that eight week old crop of *dhaincha* which was succulent and tender could be ploughed in at the time of planting of rice seedlings, while twelve week old *dhaincha* which was woody had to be incorporated in the soil eight weeks prior to planting so that it would get decomposed and be beneficial to the rice crop.

Intercropping of green manure, *dhaincha*, with 'dry broadcasting rice and burying in the former at the time of *Beushening* gave an increasd yield of 238 lb. per acre over the control and the response was equal to the application of 20 lb. N as ammonium sulphate to rice.

Investigations were carried out to assess the relative manurial efficiency of 17 green manure species grown *in situ* and brought from outside. When the green manure crops were grown *in situ*, the production of green matter varied between 3,000—10,000 lb. per acre with the different species. Maximum rice yields of 3,000 lb. per acre were, however, obtained in the plots which were grown with *Cassia leschenaultiana* and *Crotalaria striata*, which produced about 6,000 lb. per acre of green matter. Similar results were obtained, when the equal quantities of green matter at the rate of 5,000 lb. from the same green manure crops grown elsewhere was incorporated in the field.

In another experiment, the relative efficiency of the two common green manure crops *dhaincha* and sunnhemp was tested when applied in conjunction with inorganic fertilizers *viz.*, phosphate, ammonium sulphate and lime. Both *dhaincha* and sunnhemp gave identical yield responses whether grown *in situ* or brought from outside and the addition of P_2O_5 or lime did not result in any increased yield of the succeeding rice crop. The application of additional quantity of N as ammonium sulphate (30 lb. N) to green matter, resulted in premature lodging of the rice crop and considerable depression in the yield.

In an experiment to see whether *mung* crop grown for seed purposes, was comparable in manurial value to *mung* crop buried at flowering, it was found that the latter gave a significant increase in the yield of rice over the former. In the above experiment P_2O_5 applied to *mung* or rice did not result in any significant increase in yield.

The promising varieties of green manure crops were multiplied and small quantities of these seeds were supplied to other States for trial under different environmental conditions.

BOTANY

I. Maintenance and Study of Genetic Stocks

The Genetic Stock Collection now stands at 3314. During the year 164 new rice varieties were received. The new additions were received from sixteen foreign countries, *e.g.*, Burma, Ceylon, Egypt, Gold Coast, Indonesia, Iran, Italy, Japan, Malaya, Mexico, Philippines, Portugal, Russia, Sierra Leone, Taiwan and Thailand. In response to requests, seed samples of 627 genetic stocks, including six wild species, were supplied to several countries abroad and to various States in India.

The Director, Central Rice Research Institute, continued to be in overall supervision of the scheme of the Food & Agriculture Organisation for the maintenance of World Genetic Stocks of rice at five centres in the World, including Central Rice Research Institute.

Two types of rice varieties were observed to be highly pubescent among the Genetic Stocks; these are being utilized to study the inheritance of pubescence in crosses with normal hairy and glabrous varieties.

Detailed observations were completed on morphological characters and occurrence of anthocyanin pigment on all parts of rice in all the varieties in Genetic Stocks.

Based on preliminary observations, 48 promising varieties falling into four duration groups were selected for yield trial. In addition to these, 35 other early duration varieties were selected for trial under upland conditions.

II. Improving yield by

A. Introduction.—Ninety-three types, selected from the Genetic Stocks during the last year, were tried in four preliminary yield trials with the varieties arranged into four groups according to their duration. The results are presented below :

111-120 *days trial.*—In this trial 20 varieties were tried against two standards, *i.e.*, T. 635 and BAM. 12. Only two varieties *viz.*, Bankura 4, T. 1163 were as good as the standards BAM. 12 and T. 635, which yielded 1410 and 1272 lb. per acre respectively. Varieties W. 1017 (U.P.) and My. 137 (Ceylon) were found to be resistant to lodging.

121-130 *days trial.*—Nine varieties were tested for yield against the standard T. 635. Only three varieties *viz.*, AC. 790, AC. 448 and AC. 783 were as good as the control ; the latter yielded 1596 lb. per acre.

141-150 *days trial.*—Twenty varieties were tested for yield against two standard varieties T. 141 and T. 1145. Six varieties were as good as T. 141 (2159 lb./acre) and eight varieties, *viz.*, AC. 88, AC. 606, W. 3, AC. 164, AC. 3054, AC. 297, W. 540 and W. 9, gave between 25·7 to 57.0 per cent significantly higher yield than the control T. 1145 (1375 lb./acre).

151-160 *days trial.*—Nineteen varieties were tested against the standard variety T. 1242. One of the introductions, *viz.*, AC. 3035 from Madhya Pradesh yielded 3099 lb./acre which was significantly better than the yield of control T. 1242 which gave 2630 lb./acre. Nine other varieties *e.g.*, AC. 3051, AC. 345, AC. 406, AC. 163, AC. 3052, AC. 2349, AC. 2619, AC. 135 and AC. 3187 were as good as the control.

In the trial of fine grained types, out of 25 early maturing fine quality rice varieties, tried against the local standard T. 608, only one of the types *viz.*, H.S. 1, gave 35.7 per cent significantly higher yield than the standard T. 608, which yielded 1716 lb./acre. H.S. 1 is a very fine, long grained variety with white rice, taking 135 days to mature as against 122 days of T. 608. Eleven other varieties were as good as the standard.

B. Hybridization

(a) Between *japonica* and *indica* rices.

As previously reported, two parallel hybridization projects between the *japonica* and *indica* rices, one sponsored by the Food & Agriculture Organisation and the other by the Indian Council of Agricultural Research were in progress at the Institute. In the crossing programme under the Indian Council of Agricultural Research Project, 66 cross combinations remained to be completed during the year, out of which 63 cross combinations were completed. A total of 20,489 cross pollinations were made and 2,200 crossed seeds obtained. The crossed seeds obtained were rather badly damaged in the rains.

For growing the F2 generation, approximately 9·85 lakh seeds were distributed to the participating Asian countries and approximately 81,927 seeds were distributed among the participating Indian States. Details are given in Table XIII. The two schemes terminated on 31st March 1956.

Table XIII

Japonica—indica hybrids

Distribution of seeds for growing F2 generation

Name of the Country or State	No. of seeds sent	Total
I. Asian Countries		
1. Burma	2,71,750	
2. Cambodia	72,600	
3. Indonesia	90,550	
4. Malaya	1,54,250	
5. New Guinea	1,00,000	
6. Pakistan	2,400	
7. Philippines	1,86,650	
8. Thailand	34,150	
9. Vietnam	73,200	9,85,550

2—1 C. R. R. I. Cuttack/57

Name of the Country or State	No. of seeds sent	Total
II. Indian States		
1. Andamans	2,208	
2. Assam	9,615	
3. Bombay	6,040	
4. Coorg	1,165	
5. Hyderabad.	3,945	
6. Kashmir	2,719	
7. Madhya Bharat	1,180	
8. Madhya Pradesh	7,877	
9. Mysore	10,180	
10. Orissa	918	
11. Uttar Pradesh	23,417	
12. West Bengal	12,663	81,927
GRAND TOTAL		10,67,477

F2 generation.—Thirty two cross combinations between two *japonica* varieties and several *indica* varieties were raised during the year, under normal fertility conditions. Based on vigour, early maturity and number of ear bearing tillers per plant, 1308 field selections were made and out of these 104 single plant selections based on spikelet fertility, single plant yield and other grain characters, were retained for further study.

F3, F4 and F5 generations.—1392 single plant selections carried forward from previous year, were grown in F3, F4 and F5 generations. All the selections in the F3 generation (658 in number) were grown under both normal fertility (40 lb. N and 18 lb. P_2O_5) and high fertility (120 lb. N and 54 lb. P_2O_5) conditions.

Of the 437 selections in the F4 generation, 163 selections were made under normal fertility and 274 were made under high fertility conditions in the previous generation. These selections were again grown under two levels of fertility in a progeny row trial with two replications. In the F5 generation there were 274 selections, 169 promising from normal fertility and 105 from high fertility conditions, these were also again grown under the two levels of fertility in a progeny row trial with two replications. Based on the criteria employed in making selections in the F2 generation described above, 5724 field selections were made, of these 823 were finally retained; 417 selections retained were from normal fertility and 406 from high fertility conditions. The yields of the single plant selections carried forward ranged from 24 gm. to over 83 gm. It may be mentioned here that the excessive and continuous rain and strong winds in October and November adversely affected the crop, which lodged badly, particularly under heavy fertility conditions, and the yields suffered in consequence.

The comparative performance of some of the promising selections made in the F_5 generation is given in Table XIV below:

Table XIV

Performance of the indica—japonica selections

Cross combination	Indica parent mean plot yield (gm.)	F_1 sterility percentage	F_2 generation		F_3 generation		F_4 generation			F_5 generation		
			No. of selections	Mean single plant yield (gm.)	No. of selections	Mean single plant yield (gm.)	No. of selections	Mean single plant yield (gm.)	% Sterility	No. of selections	Mean single plant yield (gm.)	% Sterility
1. GEB.24 × Norin 1	21·2	63·4	51	30·1	41	56·0	45	55·1	25·5	5	44·6	17·21
2. GEB.24 × Norin 6	,,	73·7	24	31·3	25	56·6	34	55·6	24·3	3	57·3	18·35
3. GEB.24 × Norin 23	,,	68·3	5	40·2	17	45·7	10	46·0	22·5	4	49·0	21·75
4. GEB.24 × Rikuu 132	,,	68·1	36	37·0	35	48·0	19	51·9	22·7	19	51·4	22·80
5. GEB.24 × Taihoku 6	,,	73·0	22	42·9	21	46·8	23	50·7	27·3	5	50·2	17·00
6. T.90 × Aikoku	20·5	65·4	18	38·6	16	41·5	8	50·4	17·9	2	53·5	23·70
7. T.90 × Taichu 65	,,	60·2	2	22·5	11	71·3	5	63·0	26·8	2	58·5	25·50
8. T.1145 × Asahi	27·4	77·6	23	38·8	37	45·9	23	53·3	19·5	10	53·7	21·40
9. T.1145 × Taihoku 6	,,	80·9	40	34·6	55	48·3	38	51·4	18·9	28	56·6	19·60
10. BAM.9 × Norin 18	29·0	55·2	43	32·5	54	55·1	23	56·9	16·0	19	55·7	20·60
11. BAM.11 × Taihoku 6.	31·8	32·0	20	42·2	39	47·4	18	57·1	20·0	7	51·3	22·30
12. BAM.11 × Asahi	,,	27·4	19	34·6	21	44·7	14	57·1	15·4	7	54·0	17·60
13. Patnai × Rikuu 132	18·3	69·7	18	31·2	28	41·8	12	62·6	18·5	9	50·3	20·30
14. H.S. 19 × Taihoku 6	22·8	62·4	7	31·9	20	57·4	18	55·4	21·5	9	60·1	25·00

(b) Within *indica* group of rices.

As previously reported, this project was undertaken in 1948 to evolve early maturing, high yielding strains. The parents involved in the crosses were: T. 1145, T. 1242, and T. 90, the high yielding medium and late maturing types; *Sathika*, CH2, and T. 1031, the early maturing, low yielding types. During the year, 139 cultures, 99 medium grained and 40 fine grained in the F_6 generation, belonging to nine cross combinations were studied in two randomised replicated layouts with four replications in each.

In the medium grain group, while none of the cultures was significantly superior over the high yielding late maturing parents, T. 1242 and T. 90, two cultures yielded 21·2 and 16·6 per cent more than T. 1145. All the cultures were significantly superior over the early parents. *viz.* T. 1031 and *Sathika*. The flowering durations of the late maturing parents range between 110-130 days, while that of the early parents between 60–70 days. The cultures were earlier than the late maturing parents by 20–30 days.

In the fine grain group too, while most of the cultures were superior over the early maturing parent, none of them was superior over the late maturing parents, T. 90 and T. 812. All the cultures were, however, earlier by 15–30 days than T. 90 and T. 812. Most of the cultures are uniform in flowering duration and other morphological characters.

As already mentioned, there were heavy rains followed by strong winds in October and November, which caused lodging of the early cultures and germination of seeds on the panicles, resulting in low yields. The late maturing parents which were not even in flower at that time escaped damage in yield. The comparisons between the parents and the cultures, therefore, are not valid for this year.

Single plant selections were made among the more promising F_6 progenies and out of a total of 1988 field selections made in the two groups, 376 selections (250 from the medium grain and 126 from the fine grain) have been carried forward for trial next year. Besides these, 16 promising cultures in medium group and ten in fine group will be tested in a variety trial against suitable controls.

III. Breeding for non-lodging habit

As reported last year, this project has been undertaken to breed varieties which combine high yield with non-lodging habit. Fifteen varieties were tested this year in a non-replicated preliminary yield trial, under high level of fertilization (120 lb. N per acre, as 8000 lb. green manure and 400 lb. ammonium sulphate and 54 lb. P_2O_5 as superphosphate) against the local standard, T. 1145, susceptible to lodging. Four of the varieties were included from last year's trial and these were, AC. 517 (U. P.), *Nom-Dok-mi* (Thailand), *Puang Nak* (Thailand) and AC. 1951, while eleven were new types which included two from Indonesia (W. 113 and W. 130) and nine from U.S.A. (W. 210, W. 214, W. 215, W. 220, W. 221, CI. 8643, CI. 8985, CI. 8989 and CI. 8990). None of these 15 varieties lodged even under heavy rains accompanied by strong wind. In order to study the characters responsible for resistance to lodging, observations were made on plant height, ear-bearing tillers, length and diameter of first and second internode from the base, length of panicle, number of grains per panicle, sterility per cent and single plant yield.

The studies conducted on the various characters stated above did not give any clear indication of the association of any particular morphological character or characters with lodging habit.

All the U. S. A. types and *Puang Nak* were severely attacked by Gall fly and therefore yielded poorly. Among the varieties tested, AC. 1951 was the highest yielder (2410 lb./acre) followed by W. 130 (1413 lb./acre) and W. 113 (1247 lb./acre). High yielding and short statured single plants were selected in each vareiety for trial next year.

F1 generation of the following crosses made in 1954-55 and their parents were raised under high fertility conditions and observations were taken on some of the morphological characters. These hybrids were raised from the stubbles of the F1 plants grown in pots in the second crop season of 1954-55.

Cross Combination	No. of F1 plants raised
1. Ch.45 × AC.1951	15
2. CH.45 × Puang-Nak and reciprocal	20
3. CH.45 × Nom-Dok-Mi.	11
4. T.1242 × Puang Nak.	14
5. T.1242 × AC.1951	6
6. T.1242 × Nom-Dok-Mi.	3
7. T.90 × AC. 1951.	4
8. T.90 × Puang Nak	6
9. BAM. 9 × Puang Nak	2

All the hybrids and the parents, susceptible to lodging, lodged just about seven to ten days after flowering. The hybrids exhibited considerable heterosis both in plant height and number of ear-bearing tillers per plant.

Eight natural hybrids were noted in varieties CI. 8985, W. 210, W. 214, W. 221 and W. 113. The hybrid plants were prominent because of their tallness and vigorous growth. Morphological characters were noted and they are being carried forward for further study next year.

Twenty-eight fresh crosses were made between 5 high yielding but lodging Orissa varieties and some of the non-lodging foreign varieties.

IV. Breeding for upland conditions

The performance of 37 promising, early maturing (80–120 days) varieties from the Genetic Stocks, along with two standards, *Benibhog*, and B. 76–116 was tested in a preliminary replicated yield trial under purely rainfed conditions. While none of the varieties yielded more than the standard, B. 76–116, two of the varieties *viz.*, T. 657, and D. A. 10 were found to be as good as the standard, yielding 2248 and 1917 lb./acre, respectively. Three varieties

viz., T. 657, D. A. 10, and PB. 12 yielded significantly higher than *Benibhog*, the other standard, which yielded 1013 lb./acre, the increase in yield being 76·7, 50·7 and 38·4 per cent, respectively. Of these three, the first two varieties have a light red coloured rice while PB. 12 has a greyish white rice.

Five promising varieties carried forward from last year's upland varietal trial were tested for the second year under upland conditions against the standard *Benibhog*. One of the varieties, *viz.*, Ptb. 10, was found to be significantly superior over *Benibhog*, yielding 63.4 per cent more than *Benibhog*, the latter yielding 1013 lb./acre.

V. Breeding for disease resistance

As reported last year, the project of breeding high yielding, early to medium duration strains resistant to blast and helminthosporium diseases of rice, has been undertaken in collaboration with the Mycologist. During the year seven F2 families of the reciprocal crosses between Co. 13 (an early maturing variety highly susceptible to blast) and Co. 25 (a late maturing variety, highly resistant to blast) and 144 cultures in the F3 generation of the same cross combinations, were studied. All the seedlings from the F2 families were examined for leaf infection and those seedlings showing infection were rejected and the rest planted. Similarly out of the 144 F_3 cultures, 119 were rejected in the seed bed on the basis of leaf infection and the remaining 25 F_3 progenies were planted. On the basis of early to medium maturity, resistance to blast and single plant yield, 85 selections from F_2 and 26 selections from F_3, were carried forward for growing in the second crop season as F_3 and F_4 progenies respectively. Out of 85 F_3 cultures and 26 F_4 cultures growing in the second crop season, 62 selections from F_3 and 29 selections from F_4 have been carried forward to the next generation.

Five F_1 plants of the cross Co. 25 (susceptible to helminthosporium) × BAM. 10 (resistant to helminthosporium) were raised and studied. These will be carried forward to the F_2 generation in the next season.

VI. Breeding for fine quality

As mentioned last year, there is demand for fine table rices and therefore a collection of *basmati* rices from four sources, *viz.*, Dehra-Dun, Himachal Pradesh, Kulu Valley, and Punjab has been made. During the year 96 selections made in the above rices along with the bulk from each source, were grown in a progeny row trial with four replications. (i) There were no significant differences between progenies in the case of Dehra-Dun and Himachal Pradesh *Basmati*. (ii) In the Punjab *Basmati*, two progenies *viz.*, 59-40 and 21-35 were significantly better than the bulk, yielding 26.8 per cent and 19.5 per cent respectively more than the bulk. (iii) In Kulu Valley *Basmati*, three progenies *viz.*, 37-23, 15-40 and 6-15 were significantly better than the bulk, yielding 30.0 per cent, 25.9 per cent and 19.6 per cent respectively, more than the bulk. (iv) A genetic variability of 35.8 per cent and 23.0 per cent was found to be present in the progenies of the Punjab and Kulu Valley *Basmati* rice, respectively. Thirty progenies (with five selections in each) comprising of five from Himachal Pradesh *Basmati*, seven from Dehra-Dun *Basmati*, nine from Punjab *Basmati*, and nine from Kulu Valley *Basmati* have been carried forward for further trial next year.

VII. Selection in Chinese varieties

Thirty three primary selections in each of the three Chinese varieties, *viz.*, Ch. 2, Ch. 13, and Ch. 45 were tested against their respective bulks in a Progeny Row Trial with four replications in a randomised block layout.

The results showed that there were no significant differences between progenies of Ch. 2 and its bulk, while five progenies in Ch. 13 and four in Ch. 45 were significantly superior over their respective bulks giving 16·25 to 40·12 per cent higher yield than the bulk. Promising selections within these progenies are being carried forward.

VIII. Value of Bulk Breeding in the improvement of rice

The value of bulk breeding in the improvement of rice was under study. The bulk seed of six cross combinations, involving *japonica* and *indica* parents, in the F4 generation, was grown during the year in separate plots. Out of a number of field selections, 15 best single plants from each of these cross combinations will be bulked once again and grown in the coming season. The six cross combinations involved were (1) Co. 25 × *Norin* 6; (2) Co. 25 × *Norin* 18; (3) Co. 25 × *Norin* 36; (4) Co. 25 × *Asahi*; (5) Co. 25 × *Rikuu* 132; (6) GEB. 24 × *Norin* 18. The average single plant yield of the 15 final selections from each cross combination is 40·2, 40·0, 36·4, 36·1, 38·8 and 38·7 grams respectively.

IX. Genetics

(a) *New crosses made.*—For the study of inheritance of clustering habit bunched panicle habit, hairiness etc., following crosses were made and crossed seeds collected.

(1) AC.1224 × AC.3776 . . . . For super clustering habit.

(2) AC.3557 × AC.2361(GS.106) . . For bunched panicle habit.

(3) AC.3151 × AC.3042 (GS500) . . For mid-sterile spikelets.

(4) AC.949 × AC.3190 . . . . For dwarfness and cigar shaped panicle.

(5) AC.3436 × AC.1778 (GS.101) . . For hairiness.

(6) Zuiho × CP.12 . . . . . } For anthocyanine pigment of the leaf blade.
Zuiho × Ch.17 mutant & Reciprocal . . . .
Zuiho × Ch.17 . . . . . .
Ch.17 × N.136 & Reciprocal . . . . .
Ch.17 × T.136 (GS.475) . . . . . .
Ch.17 mutant × Ch.17 . . . . . .
CP.12 × Ch.17 mutant . . . . . .
CP.12 × N.136 & Reciprocal . . . . .
CP.12 × T.136 & Reciprocal . . . . .
T.136(GS.475) × Ch.17 mutant . . . . .
T.136 (GS.475) × N.136 & Reciprocal . . . }

(7) *Inter-species crosses*

Forty five cross combinations between several species of *Oryza* were attempted and seeds in some combinations were collected. Crosses with *O. latifolia* as one of the parents, in general, gave shrivelled non-viable seeds. No crossed seeds were obtained in many of the combinations, while 1-10 seeds were obtained in some.

In *O. glaberrima* var *grandiglumis*, 58.0 per cent of the spikelets were found to possess three stigmas, while 42.0 per cent had two stigmas.

(b) *Study of F1 generation.*—The following parents and F1s were studied for presence of pigment in various parts and other morphological characters.

AC.1225	All parts green, long glumes, multiple pistil, non-glutinous.
(1) AC.1225 × AC.806 .	All parts purple except leaf blade which was green. Intermediate glumes and single pistil, segregation for non-glutinous and glutinous character in the ratio of 3 : 1.
AC.806	All parts purple except pulvinus and internode ; single pistil, normal glumes and glutinous.
(2) AC.1107 × AC.806 .	Purple pigment dominant (though diluted) except in leaf blade, where it was inhibited; unnotched kernel, segregation for endosperm character in the ratio of 3 nonglutinous : 1 glutinous.
AC.1107	All parts green and normal.
(3) AC.806 × GEB.24 .	Purple pigment dominant (though diluted) except in leaf blade, where it was inhibited. Segregation for endosperm character as in the above two crosses.
GEB.24	All parts green and normal, endosperm non-glutinous.
AC.967.	Rudimentary auricle.
(4) AC.967 × *Shala* .	Auricle normal.
Shala	Auricle, ligule, absent, fully fertile spikelets, non-shattering and normal glumes.
(5) *Shala* × AC.1244 .	Auricle, ligule present, glume slightly longer than AC. 1244, fully sterile and fully shattering.
AC.1244	Auricle, ligule present, glume long, fully fertile and non-shattering.
(6) *Shala* × AC.1246 .	Auricle, ligule (longer than AC.1246) present, glume normal, fully sterile and fully shattering.
AC.1246	Ligule (small) and auricle present, normal glume, fertile and non-shattering.
(7) *Shala* × AC.1247 .	Ligule (longer than AC.1247) and auricle present, glume normal, fully sterile and fully shattering.
AC.1247	Auricle, Ligule (small) present, glume normal, fully fertile and non-shattering.

NOTE.—AC.1244, AC.1246 and AC. 1247 varieties belong to *O.glaberrima*. The two parents crossed were in all cases non-shattering and fully fertile, but the Fr in all cases was fully sterile and fully shattering. Probably complementary genes determine the shattering and spikelet fertility.

(8) *Shala* × AC.806 .	Pigment dominant in all parts where present in AC.806 including leaf blade, Auricle, ligule present, Xenia for endosperm character.
(9) *Shala* × AC.1224 .	All parts green, auricle, ligule (longer than AC. 1224) present, glumes slightly longer than *Shala*-spikelets at the tips clustered.
AC.1224	All parts green, glume long, clustered habit, rice white.

(c) *F2 studies.*—(i) *Awn Character.*—*Zuiho* and *Fukoku* are two *japonica* types from Japan. *Zuiho* is awnless, while *Fukoku* has short awns. The F1s of these parents with the various *indica* varieties were all awned. In the F2 generation ratios of 9:7; 27: 37 ; 81:175; 243: 781 and 729:3367 of awned (all degrees of awning) : awnless were obtained. One of the ratios *viz.*, 81:175 has been confirmed by F3 performance. Thus for the production of awns six genes seem to be necessary. Whether these genes have an additive effect remains to be studied.

(ii) *Pigmentation.*—(1) *Leaf blade*—Three types with pigmented leaf blade, called purple (CP. 12), purple wash (Ch. 17) and faint purple wash (Ch. 17 mutant) were crossed between themselves as well as crossed to several varieties with green leaf blade. The pigmented condition was dominant over its absence except in crosses with CP. 12, where due to the action of inhibitory gene, the purple pigment was not expressed in the F1. The various segregations obtained are given in Table XV below:

TABLE XV

F2 segregation for leaf blade pigmentation in crosses between pigmented and nonpigmented leaf blade

Cross	F2 segregation
1. Purple leaf blade × Green	13G : 3P; 55G : 9P or 229G : 27P.
2. Purple leaf blade × Purple wash	39PW : 12P : 13G.
3. Purple leaf blade × Faint purple wash	117PW : 36P : 48FPW: 55G.
4. Purple wash × Green	9PW: 7G; or 27PW : 37G.
5. Purple wash × Faint purple wash	3PW : 1FPW.
6. Faint purple wash × Green	27PW : 9FPW : 28G.

P=Purple; PW=Purple Wash; FPW=Faint Purple Wash; G=Green.

The above F2 segregations are explained on the assumption that six genes are involved in the inheritance of leaf blade pigment out of which *AA* and *CC* are basic and chromogen genes, respectively. *LpLp* produces purple pigment in the presence of *AA*, *CC* and *Ld Ld* (localization gene) and *Lpw* produces purple wash pigment in the presence of *AA*, *CC* and *Ld Ld*. *L'd L'd* is the mutated gene which causes dilution of purple wash pigment to faint purple wash; *Ilp Ilp* is the inhibitory gene pair which is epistatic over *Lp Lp* but not over *Lpw Lpw*. *LpLp* is epistatic over *Lpw Lpw*. Thus the genic constitutions of the three pigmented parents are:—

		Leaf blade colour
CP. 12	= *AA CC Lp Lp lpw lpw Ld Ld ilp ilp*	Purple.
Ch. 17	= *AA CC lp lp Lpw Lpw Ld Ld Ilp Ilp*	Purple wash.
Ch.17 mutant	= *AA CC lp lp Lpw Lpw L'd L'd Ilp Ilp*	Faint purple wash.

The F2 hypothesis was confirmed by F3 results.

(2) *Apiculus and stigma colour.*—In a cross between AC. 1247 (green apiculus and purple stigma) and AC. 1246 (Purple apiculus and white stigma) the F1 was purple apiculus and purple stigma and in the F2 a monogenic ratio of 3P:1G and 3P:1W was obtained for apiculus and stigma colours respectively. A close linkage with a cross over value of 10.5 per cent was observed between apiculus colour and stigma colour.

In another cross between *Baok* (green apiculus and purple stigma) and C. 28-16 (green apiculus and white stigma), the F1 was purple apiculus and purple stigma, and the F2 segregated in the ratio of 81 purple: 175 green apiculus, and 27 purple: 37 white stigma. In the joint segregaion one class *viz.*, purple apiculus and white stigma was completely absent. The segregation is explainable on the basis of pleiotropy as shown below :

Joint segregation in cross C. 28-16 × Baok

	Purple apiculus Purple stigma	Purple apiculus white stigma	Green apiculus purple stigma	Green apiculus white stigma	Total
Observed	87	0	23	162	272
Expected on pleiotropy (81:0:27:148).	86·03	0	28·68	157·29	272
	χ^2 = 1·364		P=0·5 —0·7		

In still another cross between purple spreading apiculus and green apiculus and F2 segregation of 9 purple spreading : 3 purple : 4 green was obtained.

(3) *Pigmentation in ten plant parts.*—Inheritance of pigmentation in these parts was studied in the cross *Zuiho* × *Dular*. *Zuiho* is awnless and non-pigmented while *Dular* has pigment in leaf sheath, tip and margin, auricle, ligule, junctura back, internode, leaf axil, septum, apiculus, stigma, lemma and palea and is awnless. In F1 the pigment was dominant over its absence and the hybrid was awned. The following F2 segregations were obtained:

1. Leaf sheath . . . . . 162P : 94G.
2. Tip and Margin . . . . . 9P : 7G.
3. Ligule . . . . . 9P : 7G.
4. Junctura back . . . . . 9P : 7G.
5. Leaf axil . . . . . 3P : 1G.
6. Internode . . . . . 162P : 94G.
7. Septum . . . . . 27P : 37G.
8. Apiculus . . . . . 3P : 1G.
9. Lemma and palea . . . . . 3G : 1Gd.
10. Stigma . . . . . 9P : 7G.
11. Awn character . . . . . 81Awned:175Awnless.

Note.—P=Purple; G.=Green; Gd=Gold.

In all cases except leaf sheath, the F2 segregations were confirmed by F3 performance. In the case of leaf sheath due to close planting and late observations the pigment could not be properly classified and the study was therefore abandoned. On the basis of F2 segregation, confirmed by F3 performance, there appear to be 27 gene pairs (including the two basic genes) involved to cover the expression of pigmentation in the characters enumerated above. Some of the genes involved are common to two or more plant characters.

(4) *Auricle, ligule and junctura.*—In a cross between *Shala* (in which auricle, ligule and junctura are absent) and *Salak* (auricle, ligule, junctura present), the F2 segregated into a ratio of 255:1 of presence to absence, showing the action of four independent genes, each capable of producing the organ in question. There was complete linkage between the three parts there being no F2 segregates in which the three characters did not go together.

(5) *Coleoptile.*—The pigment in the coleoptile was found to be governed by a maximum of six genes as F2 ratios of 9 : 7 ; 27 : 37; 243-781 and 729 : 3367 of purple to green were obtained in the various cross combinations studied.

(iii) *Chlorophyll deficiencies.*—(1) *Albino.*—Albinos were observed in the progenies of the variety *Basmati* from Himachal Pradesh. Two to four independent recessive genes were found to govern the occurrence of this mutation. Ratios of 15:1; 63:1 and 255:1 of green to albino were obtained in the various progenies studied.

(2) *Xantha.*—Lethal yellow seedlings were observed in one of the F4 progenies of a *japonica-indica* hybrid. A segregation of 3 green : 1 Xantha was obtained.

X. Cytology.

Twelve wild *Oryza* species in addition to two cultivated species were under study. The somatic chromosome numbers in these were either 24 or 48. From the data of natural distribution, chromosome number, morphological and anatomical characters a division of the genus into three sections was tentatively proposed. The grouping of the species suggested is given below. The somatic chromosome numbers of the species are indicated in brackets.

I. Section Sativa includes *O. sativa* (24), *O.glaberrima* (24), *O.perennis* (24), *O.breviligulata* (24) and *O. australiensis* (24). II. Section Officinalis includes *O.officinalis* (24), *O.minuta* (48), *O.eichengeri* (48), *O.latifolia* (48), and *O. alta* (48). III. Section Granulata includes *O. granulata* (24), *O.brachyantha* (24), *O.coarctata* (48) and *O.ridleyi* (48).

Interspecific hybridizations have been made to test relationships between the species. The following F1s of species in the first section have been studied. *O.sativa* × *O. perennis*, *O. sativa* × *O. glaberrima*, *O. sativa* × *O. breviligulata*, and *O.glaberrima* × *O.perennis*. The last three hybrid combinations were highly sterlile, but after continued vegetative propagation, some seeds set. In intersectional crosses, the F1s of *O. sativa* × *O.eichengeri* and *O.glaberrima* × *O.eichengeri* were studied. These hybrids were completely sterile. Cytological study of the latter hybrid showed presence of irregularities in meiotic division resulting in complete gametic sterility.

Chromosome variants of *O.sativa* were grown. A haploid plant was found in a segregating F3 population of a *japonica* × *indica* hybrid. This plant is completely sterlile and is being kept alive by vegetative propagation. A

triploid plant was found in a field culture of T. 1242, an improved variety of Orissa. The triploid showed increase in spikelet size and awns as compared to original diploid and was sterile.

Tetraploids were secured by colchicine treatment of germinating seedlings. The tetraploids were of two classes, homozygous types derived from the improved strains GEB.24, SR.26B, *Indrasail* and *Seta*, and hybrid tetraploids derived from hybrids between *japonica* and *indica* varieties. All the tetraploids showed increases in spikelet size, development of awns and semisterility. The homozygous tetraploids were compared for their semisterility and it was found that there was large variability in their seed setting. In tetraploid plants of S.R.26B, grown under uniform conditions, spikelet fertility ranged from 44 to 76 per cent, the mean was 62 per cent and standard deviation 9 per cent.

Under field conditions ear bearing tillers in the tetraploids were consistently lower than their corresponding diploids. Increasing the spacing between plants from 6 to 9 inches resulted in an increase in the tiller number in diploids, but not in the tetraploids. In one experiment, seedlings of diploids alone or tetraploids alone, or combinations of diploids and tetraploids were planted in rows 6″ apart with 12″ between rows. In this trial, it was seen that the proximity of diploid plants reduced tillering and yield in tetraploid plant.

XI. Plant Physiology

The photoperiodic response of some wild species of *Oryza* was studied. Thirty days old seedlings of species were subjected to short-day photoperiod of 8 hours for 21 days. Results are presented below :

TABLE XVI

Photoperiodic response of some wild species under short day treatment

	Flowering duration in days		Photoperiodic response in days
	Control	Short-day treated	
1. *O.australiensis*	120	107	13
2. *O.barthii*	121	119	2
3. *O.brachyantha*	90	78	12
4. *O.cubensis*	118	115	3
5. *O.glaberrima* var. *grandiglumis*	109	82	27
6. *O.officinalis*	125	78	47
7. *O.stapfii*	124	90	34
8. *O.perennis*	120	120	..
9. *O.perennis* var. *longistaminata*	118	97	21
10. *O.breviligulata*	78	76	2
11. *O.eichingeri*	113	88	25
12. *O.latifolia*	109	87	22
13. *O.minuta*	105	98	7
14. *O.coarctata**	125	88	37

**O.coarctata* was raised from the stubble of previous year.

The response to photoperiod varied from nil in *O.perennis* to as high as 47 days in *O.officinalis*.

XII. Embryoculture

Embryos of varying ages from 5 days to 15 days, were cultured in Randolph's nutritive medium in test tubes. It was found that embryos of 6 days age and above could be cultured, although the seedlings from the six days old embryos were very weak and spindly. The seven days old embryos and above grew quite normally, the vigour increasing with the age of embryos upto ten days, beyond which there were no visible differences.

XIII. Jeypore Scheme

Under a scheme sponsored by the Indian Council of Agricultural Research at this Institute a botanical survey of the Jeypore tract of Orissa State was started in 1955-56 for collection of wild and cultivated rices. This tract forming the south west part of Orissa adjoining Madhya Pradesh and Andhra possesses great varietal diversity as regards rice and hence considered a secondary centre of origin of cultivated rice in India.

During the year a third of this area was surveyed and 709 seed samples of rice varieties cultivated in this area and 22 samples of wild rice (*O. sativa* var. *fatua*) and one sample of *O. granulata* were collected.

The collection included widely varying forms as regards grain size, shape, colour of lemma, palea, nature of sterile glumes, presence of awn etc. To cite a few instances, two glutinous, two semiglutinous types, three types having the sterile glumes as long as lemma and palea, and one type occasionally showing disproportionate growth of sterile glumes, lemma and palea were noted. The wild type *O.sativa* var. *fatua* showed considerble variation in all the morphological characters mentioned above, especially in the length and colour of awn.

CHEMISTRY

I. Phosphate changes in water logged soils

(a) Investigations have been in progress to study the nutrient status of water logged soil. In the earlier studies nitrogen transformation in the rice soils was examined and during the current year phosphate changes in rice soils under water logged conditions have been studied. It was seen that in a typical low land rice soil at Cuttack, soluble phosphate extractable by Morgan's reagent, increased from 1·6 mg. P_2O_5 per 100 gm. in dry soil to 4·1 mg. in 100 gm. after a period of seven days of water logging. The amount of soluble phosphate in soil solution also increased with depth of water on the surface of soil, and was related with the degree of reduction of sub-soil as measured by the amount of soluble iron in soil solution. Table XVII shows the changes in soluble phosphate and soluble iron on water logging with different depths of standing water.

TABLE XVII

Soluble phosphate and soluble iron in soil with different depths of surface water

Depth of surface water	Soluble phosphate in soil solution ppm. P_2O_5	Soluble iron in soil solution ppm.
1. Surface film of water.	0·09	13·9
2. 2·5 cm. depth	0·23	21·9
3. 5·0 cm. depth	0·23	21·0
4. 10·0 cm. depth	0·46	31·0

The above results show that soil under water logged condition may be considered more fertile from the point of view of phosphate availability.

(b) Examination of phosphate status of soil under field conditions at various stages of crop growth was undertaken and soluble phosphate in soil solution was measured. It was found that soluble phosphate was relatively higher in soil during the month of September than later during October and November. The phosphate content of irrigation water from the Taldanda canal in the month of September, the period of high goods in the year was also higher than that during the months of October and November. The flooded condition in September and the high phosphate content the canal water used for irrigation appear to have influenced the higher availability of phosphate during September as compared to later months.

(c) Incidental to above study, phosphate content of some well waters in the Institute area and the town of Cuttack was also examined. Some wells in this area showed fairly high phosphate content and there was general tendency for wells close to the Mahanadi river to have higher phosphate content than those away from it.

II. Phosphatic manurial trials

A number of phosphatic manurial trials to study the cumulative and direct effect of application of superphosphate on the growth and yield of rice have been in progress during the year.

(a) The two experiments on cumulative action of superphosphate, which have been in progress for the last 6 years, one in pots sunk *in situ* and the other in field condition were continued this year also. Small yield increases due to continuous use of superphosphate were obtained as in the past year. These increases were, however, not significant.

(b) Direct effect of application of superphosphate on growth and yield was studied both under field and pot experiments, with heavy doses of P_2O_5, *i. e.*, upto 1,200 lb. P_2O_5 per acre. Response to phosphate application was seen at the vegetative stage of plant growth. Number of tillers and dry matter produced per plant were higher with phosphate application than with no phosphate. No increase in yield of grain was obtained due to phosphate application except in the pot experiment, where level of 1,200 lb. P_2O_5 per acre only, gave significant increase in yield.

(c) A manurial trial was conducted with a view to assess how far the rice crop grown in association with *dhaincha* would benefit by such association, especially when phosphate application to crop was done at sowing time. Rice and *dhaincha* were sown together in plots fertilized with phosphate at two levels, *i. e.*, 50 lb. and 100 lb. P_2O_5 per acre. When the crop was 5 weeks old the green manure was uprooted and removed in some plots and in other plots the green manure was buried in. The yield of rice obtained in the different treatments are presented below:

TABLE XVIII

Influence of phosphate application and green manuring on yield of rice (Mean yield of grain gm. per 10 plants)

Treatment	No P_2O_5	50 lbs. P_2O_5 acre	100 lbs. P_2O_5 acre	Mean
No green manure	84·8	86·0	91·3	87·3 (100)
Green Manure uprooted and buried	126·8	146·0	133·0	135·3** (155)
Green Manure uprooted but not buried in	96·4	107·3	110·3	105·0** (120)
Mean	102·7 (100)	113·1 (110)	111·5 (108·5)	

** Significant at 1 per cent level

C. D. for comparing marginal treatment means = 16·9

C. D. for comparing individual treatment means = 29·4

The phosphate application did not have any effect on rice yield in any of the treatments. It is of interest to note that association of green manure crop with rice upto a period of 5 weeks significantly increased the yield of rice even in the treatment where the green manure was uprooted and thrown away. Green manure buried in increased the yield of rice by 55 per cent.

III. Sampling technique for water-logged soils

Nutrient status of soil under water-logged state is different from that under aerated condition and the soil has therefore, to be sampled under representative field condition to determine nutrient status of soil at any time during the growth period of the crop. A simple sampling technique to get a representative sample of water-logged soil for chemical analysis was developed, and is described below.

The apparatus necessary for collecting samples are, a glass funnel about 5" diameter, a watch glass about 6" diameter and wide mouthed screw cap bottles for transport of samples from field to the laboratory. The method of sampling is as follows:

Funnel is placed in an inverted position on the spot to be sampled, taking care that the supernatent water is not very much disturbed. The funnel is then slowly pressed in to the soil profile till all clear water flows out of the open stem of the funnel and the soil puddle is seen reaching the junction of the stem and cone. The watch glass is then gently inserted into the soil by the side of the funnel with convex side up and slipped under the funnel to hold the soil sample firmly in position. The funnel along with the watch glass held in this position is then taken out and extra water allowed to drain off by keeping the funnel in upright position with stem downward for about half a minute. The soil sample thus collected is then put into a wide mouthed bottle, covered air-tight and taken to the laboratory for analysis. A few representative samples are collected in this manner from an area and a composite sample prepared for analysis.

Water logged soil samples collected in the above manner were centrifuged for 5 minutes at 2,500 r. p. m. to collect a clear soil solution for measurement and analysis. Quantity of soil solution obtained per unit weight of soil sample taken was fairly constant. Also ratio of weight of centrifuged soil (after decanting off the soil solution) to that of the original sample taken, was determined for a number of samples and was found to be constant.

Variations between moisture status of samples collected at different periods and under varying depths of surface water were estimated. The soil moisture under different conditions was found to be in the range of 41-44 per cent for a low land clay soil.

IV. Growth and nutrient assimilation studies

(a) Investigations on growth and assimilation of N, P_2O_5, K_2O and SiO_2 by two short duration varieties, Ptb. 10 (110 days) and Mtu. 15 (125 days), were conducted during the second crop season (December-April). Both varieties were grown at basal manurial dose of 30 lb.N, 30 lb. P_2O_5 and 20 lb. K_2O per acre.

Growth data regarding dry matter, tillers formed, interval of leaf emergence and elongation of internode of main stem etc. were recorded. Plant samples were collected for analysis every tenth day to estimate the quantity of nutrients.

Vigorous growth period during the vegetative stage for both varieties started about 10 days after transplanting and continued for 4-5 weeks depending upon the duration of the varieties. Tillering continued to increase upto ear-initiation stage after which there was a rapid fall in tiller number due to decay of late and ill-developed tillers.

Uptake of nutrients by the two varieties followed the same trend upto ear-initiation stage. After this the two varieties exhibited a differential uptake of nutrients. Ptb.10 showed no increased uptake of N, P and K while Mtu. 15 continued to assimilate these nutrients right upto maturity. Increase in dry matter produced was more after ear-initiation stage and nearly 60 per cent of the dry matter produced was accounted for during this period. The crop was found to remove appreciable quantities of N and P_2O_5 after ear-initiation period. The data indicate that if the soil is deficient in these nutrients or if uptake of these nutrients at and after flower initiation is restricted due to any environmental conditions in soil, the yield will be pulled down.

Ptb. 10 was observed to have partially decayed roots at flowering stage. This condition of Ptb. 10 might have adversely affected nutrient uptake after flowering by this variety.

Nutrients removed per acre by the two varieties from soil were as follows:

TABLE XIX

Quantities of different nutrients removed by crop lb./acre

	Yield	N	P_2O_5	K_2O	SiO_2
*tb.*10					
Grain	1,800	14·4	12·2	5·7	139·3
Straw	1,780	8·0	6·4	28·8	224·2
TOTAL	3,580	22·4	18·6	34·5	363·5
*Mtu.*15					
Grain	3,242	25·4	22.8	10·2	165·1
Straw	3,840	15·9	7·6	69·1	476·9
TOTAL	7,082	41·3	30·4	79·3	642·0

(b) Solution culture studies were undertaken to compare the relative assimilation of nitrogen by Ptb. 10 (*indica*) and Aikoku (*japonica*) under graded nitrogen levels of 0, 5, 20, 60 and 150 ppm. nitrogen during the 2nd crop, (December-April) season. To get identical conditions of growth both at vegetative and reproductive stages, seedlings were grown at long photo-periods of 16 hours for 20 days. Transplanted plants were also kept at long photo-period of 16 hours for 30 days, followed by short photo-period of 8 hours up to flowering. Influence of different levels of nitrogen on yield and other plant characters is shown in the following table.

TABLE XX

Effect of different nitrogen levels on yield and various morphological characters of Ptb. 10 and Aikoku

Variety	Ptb. 10 (*indica*)					Aikoku (*japonica*)				
Levels of nitrogen ppm.	0	5	20	60	150	0	5	20	60	150
Ear No./pot . .	8	18	38	54	54	4	23	42	60	62
Weight of earheads gm./pot . . .	5·0	24	64	61	49	1·5	19	45	73	70
Mean No. of filled grain/panicle . .	27	48	71	55	48	10	38	41	45	7
Mean No. of chaff per pancile . .	13	10	8	11	16	21	13	20	20	23
Mean length of panicle cm . .	15·8	16·0	18·3	17·8	16·9	11·0	13·3	13·8	14·4	15·1
1000 grain weight gm.	19·3	22·7	23·8	21·0	19·2	20·5	23·3	23·0	22·7	21·8

Variety	Ptb. 10 (*indica*)					Aikoku(*japonica*)				
Nitrogen Per cent.										
Ear . . .	1·04	1·30	1·65	1.98	2·16	1·30	1·33	1·42	1·53	1·87
Straw . . .	0·58	0·65	0·75	2·59	3·46	1·00	1·08	1·20	1·38	2·70
Root . . .	0·68	0·72	0·94	2·00	2·34	1·04	10·4	1·24	1·36	2·66

Ptb. 10 had a higher top length than *Aikoku* at all levels of nitrogen. Maximum top length for Ptb. 10 was obtained at 20 ppm. N, while that of *Aikoku* at 60 ppm. N, after which both varieties showed decrease in top length. Roots of Ptb.10 at lower nitrogen levels were remarkably longer than that of *Aikoku*. At very high nitrogen level of 150 ppm. Ptb. 10 had very short roots with decrease in absorption surface. *Aikoku* the *japonica* variety, did not show such sharp differences in root length at different nitrogen levels. This suggested that under field conditions at lower fertility level in the surface soil, Ptb. 10 may be capable of throwing longer roots deep down in the soil in search of nutrients. Grain yield of Ptb. 10 (*indica*) increased up to 20 ppm. and showed decline at higher levels of nitrogen. *Aikoku*, (*japonica*) continued to yield higher with increase in N levels up to 60 ppm. N and there was no appreciable fall in yield even at 150 ppm. N. Though both varieties showed increase in effective tillers with increase in nitrogen level the yield of grain of the *indica*, however did not follow this trend because increasing nitrogen levels beyond 20 ppm. adversely affected the length of panicle, number of filled grain per panicle and 1,000 grain weight. Nitrogen percentage in grain, at optimum levels of nitrogen for production of grain for the two varieties was higher in the *japonica* than in the *indica*.

Nitrogen metabolism of the plant as measured by ratio of soluble nitrogen to total nitrogen did not show any marked difference between the *indica* and the *japonica* varieties up to vegetative stage, but at the reproductive stage, it was found that the *indica* variety was not able to utilize nitrogen as efficiently as the *japonica* variety did.

Thus varieties showed differential response to nitrogen. *Aikoku* responded well up to 60 ppm. nitrogen, whereas Ptb. 10 responded well only up to 20 ppm. nitrogen. The response at lower nitrogen levels was higher for Ptb. 10 than for *Aikoku*. Ptb. 10 (*indica*) is therefore found adapted for low nitrogen levels as ompared to *Aikoku* (*japonica*).

(c) Photo-period and fertilizer response of short duration *indica* (Ptb. 100) and *japonica* (*Aikoku*) were studied. These varieties were grown at three nitrogen levels, (*viz*., 0, 0·5 and 2 gm.) nitrogen per pot (22 lb. soil) under three day-length treatments, *viz*., 0·5, and 2·0 gm. short day (8 hours), normal day-(about 12 hours) and long day (16 hours). Flowering of these varieties was hastened under short day treatment, the response being more with Ptb. 10 than with *Aikoku*. The varieties did not flower at all under long day treatment. The degree of manuring did not affect flowering duration. Mean tillers per plant increased with nitrogen levels at all photo-periods, the response at higher nitrogen level being more at normal photo-period than at short photo-period.

Yield at normal photo-period treatment, however, could not be recorded because of severe borer attack, hence no comparison of grain yield at different photo-periods could be done. The yield of two varieties at short photo-periods was as follows:—

TABLE XXI

Dry matter produced at short photo-period of 8 hours gm./pot

	Ptb.10			Aikoku		
Levels of N. gm./pot.	0·0	0·5	2·0	0·0	0·5	2·0
Grain	21	30	29	21	27	47
Straw . . .	14	19	29	12	17	32
Root . . .	3·5	4·3	2·2	1·1	1·4	1·9

V. Influence of growth promoting substances on yield and growth of paddy

Effect of alpha-napthalene acetic acid sprayed on to standing crop at various stages of growth was investigated under a field trial. Acid concentration of 50, 100, 200 and 500 ppm. were sprayed at maximum tillering and flowering stages. No influence on yield and growth of paddy could be obtained due to these treatments.

ENTOMOLOGY

A. FIELD PESTS

I. Varietal Susceptibility investigations

(a) *Gall fly.—Pachydiplosis oryzae* (W. M.) Mani—(i) The study of relative susceptibility of the Genetic Stock collection of the Institute to gall fly was continued by examination of samples drawn at peak period of pest incidence. One hundred and ninety two varieties only had been studied last year. During the current year 200 more were examined in early maturing varieties of 90—110 days duration. The percentage of attacked tillers ranged from 10·9 in R14-*Badshahbhog* to 96·1 in T. 828. The varieties were classified according to the degree of susceptibility and the frequency table of percentage incidence is given below:—

TABLE XXII

Reaction of varieties to Gall fly

Percentage incidence	Number of varieties
0·0 to 10·0	0
10·1 to 15·0	1
15·1 to 30·0	20
30·1 to 50·0	67
50·1 to 70·0	85
70·1 to 90·0	26
90·1 and above	1

(ii) With a view to determining the relationship between gall fly incidence and certain plant characters, *viz.*, scent and colour, 5 green non-scented, 5 green scented and 6 purple pigmented varieties were selected and grown in a randomised block with 4 replications. Samples from all varieties in all the replications were examined during the peak period of gall fly infestation. The results are tabulated below:

TABLE XXIII

Reactions of scented and pigmented varieties to Gall fly

Group	Name of the variety	Mean percentage infestation
Green non-scented	T. 272	54·68
	T. 285	52·96
	GEB. 24	51·42
	T. 832	49·72
	T. 264	46·02
Green scented	B2	39·10
	R14 *Badshahbhog*	25·90
	BK15	19·18
	Jeeragasamba	14·22
	T. 412	13·64
Purple pigmented	T. 258	46·98
	Cross No. 4 × Ajan No. 34	40·87
	C. P. 6	36·11
	Balungamardan	35·20
	Cross No. 1 × *Sultugurmatia*	34·86
	C. P. 9	26·61
	C. D. (0·05)	9·24

There were wide variations in gall fly infestation between the varieties in each group, the infestation in the green non-scented varieties being more than in the green scented or purple pigmented varieties. Among the scented varieties, there was wide variation in gall fly infestation which might be due to the degree of scent.

As a consequence of gall fly infestation, profuse tillering was observed in the varieties. Most of these innumerable small tillers were again infested resulting in higher incidence in the varieties having larger number of tillers.

(b) *Stemborers.*—*Schoenobius incertulas* Wlk.; *Scirpophaga innotata* Wlk.; *Chilo* spp. etc.

In the study of varietal susceptibility some varieties were added and some omitted from the previous year's list of varieties. In all, the relative susceptibility of 129 varieties was studied by examination of random samples at earhead stage. The percentage of white earheads ranged from 0·09 in TKM. 6 to 30·05 in variety Y.2009-2. The frequency table for the percentage incidence is given below:

TABLE XXIV

Reaction of varieties to stemborers

Percentage incidence	Number of varieties
0·1 to 1·0	29
1·1 to 5·0	81
5·1 to 10·0	17
10·1 to 15·0	1
15·1 to 20·0	nil
20·1 to 25·0	nil
25·1 and above	1

II. Incidence of Pests in relation to agronomic practices

Studies on the seasonal abundance of pests were continued with the object of determining the factors favourable for the prevalence and abundance of pest and the relationship between the incidence of pests and the season, the time of planting and the age of the crop.

In this experiment 30 days old seedlings of two varieties, *viz.*, Ch. 45 and DI. 4, were planted at fortnightly intervals from July till February. The pest infestation wa. estimated by examination of samples drawn from each planting when the crop was 60 and 90 days old and at harvest. The results obtained this year are discussed below:—

(a) *Gall fly.*—The incidence of gall fly commenced by middle of July and extended till January. The peak period of gall fly infestation was observed from middle of September till middle of October. As in previous years, 90 days old crop showed more infestation than 60 days old crop, irrespective of the date of transplanting.

The prevalence of the flies was studied at light traps and the maximum population was found during the period, 19th September till 17th October. The peak of natural parasitisation of the gall fly grubs was observed to be in the last week of December.

(b) *Stemborers.*—Studies on stemborer incidence indicated that the infestation started in the nursery during early September. The incidence was highest during February and March.

Moth catches at light traps indicated two peaks of the prevalence of moths, in November 1955 and in March 1956, of which the latter was more serious. The infestation by the brood that emerged in March was manifest as dead hearts in plantings done during February, and as white ear heads in plantings done in December and January.

The natural parasitisation of stemborer eggs was 28·05 per cent in February and 40·0 per cent in March.

III. Insecticidal trials to control pests

1. *Efficacy of different insecticides.*— (a) *Gall fly*—The comparative efficacy of four organophosphorous insecticides, (1) Ekatox, (2) Folidol, (3) Basudin, and (4) Malathion, and two chlorinated hydrocarbons, (1) Endrin, and (2) Hortex, in controlling gall fly was investigated.

The variety grown was GEB. 24. The treatments included (i) irrigating the nursery with the insecticides, (ii) irrigation followed by post-transplanting sprayings (iii) post-transplanting sprayings according to the prevalence of the pest and (iv) check. Infestation in the different treatments was estimated by examination of samples at the peak period of pest incidence. Among the treatments nursery irrigation followed by post-transplanting spraying was most effective.

The efficacy of insecticides was in the following descending order :— Ekatox, Folidol, Basudin, Malathion, Endrin and Hortex.

(b) *Stemborers.*—Similar insecticidal trials were also conducted to study the efficacy of the insecticides for the control of stemborers in small plots of 3′×3′ with the variety, Ptb. 10.

The insecticides tried were Folidol, Basudin, Shell-Endrin, Gartolit-Extra, Gartolit-54 and Duolit-Extra. The treatments included, post transplanting sprayings (3 times), according to the prevalence of the moths, irrigating the plants (3 times) with respective insecticides, and check. Infestation in the different treatments was estimated by examination of individual plants at weekly intervals. The efficacy of the insecticides in post-transplanting spraying was in the following descending order:—Endrin, Folidol, Basudin, Gartolit-54, Duolit-Extra and Gartolit-Extra. The efficacy of the insecticides in irrigating the plants was in the following descending order:—Gartolit-Extra, Basudin, Folidol, Gartolit-54, Endrin and Doulit-Extra. The results need to be confirmed in further trials.

2. *Efficacy of different methods of application of Folidol-E* 605 *E.C. in the control of rice pests.*—(a) *Gall fly.*—(i) With a view to determining the most effective and economic method of application of Folidol E 605 to control gall fly, an experiment was conducted with the variety GEB. 24, with 8 treatments as given below in the Table XXV :

TABLE XXV

Control of Gall fly with Folidol-E 605

Treatment	Mean percentage incidence of gall fly (Angular values)	Mean No. of tillers per unit area of 1′ × 1′	Mean No. of gall fly attacked tillers per unit area of 1′ × 1′	Yield in pounds per acre	Percentage over check
T_1 Check or control	43·21	100·95	49·91	1977·41	100·00
T_2 Nursery irrigated	43·32	85·45	40·58	2034·02	102·86
T_3 T_2 + Crop sprayed 4 times	44·47	65·67	33·13	2164·45	109·46
T_4 Nursery sprayed + crop sprayed 4 times	44·37	70·95	35·67	2193·20	110·91
T_5 Nursery sprayed + crop sprayed 6 times	41·16	55·41	24·89	2516·92	127·28
T_6 Seedlings dipped prior to planting	42·60	95·58	43·88	1942·34	98·23
T_7 Crop sprayed 4 times	44·10	70·00	35·28	2036·82	103·01
T_8 Both treatments as in T_6 and T_7	43·30	64·14	32·30	2255·09	114·04
C.D. (0·05)	31·94	21·72	11·84	184·88	

In the above experiment, sprayings were discontinued at the flag-leaf stage as the gall fly incidence at that stage would affect only the subsidiary and tertiary tillers which however do not contribute towards yield. Random samples were uprooted during the peak period of infestation and the tillers (including primary, secondary and tertiary) were examined for pest incidence.

It may be seen from the table that there are significant differences in yield in the sprayed plots. Treatment with 6 sprayings (T5) has given the best yield as compared with treatments with four sprayings (T3), (T4) and (T7). Nursery irrigation alone (T2) or dipping alone (T6) or spraying alone (T7) has not given any significant increase in yield.

There were significant differences both in the number of tillers and the number of gall fly attacked tillers per unit sampling area in the different treatments. The number of tillers was significantly more in the unsprayed treatment (T1, T2 and T6) due to the fact, that early infestation by gall fly induced

vigourous tillering after the death of primary and secondary tillers. In the sprayed treatments, the early incidence was considerably checked resulting in the survival of primary and secondary tillers on account of which there was no profuse tillering. In the case of unsprayed treatments with profuse tillering, the newly formed tillers in turn were again infested increasing the number of gall fly attacked tillers.

The efficacy of the spraying was borne out by the reduction in the mean number of attacked tillers per unit area and the increase in yield, but though the Folidol treatments significantly reduced gall fly incidence and thereby contributed to increase in yield significantly, yet when the percentage of incidence of gall fly is taken into account, there was apparently no significant difference between them. This is because, the percentage incidence was based upon the total number of tillers including the subsidiary and tertiary ones, which were heavily infested with gall fly.

(ii) *Efficacy of low volume spraying.*—The comparative efficacy of spraying with a high gallonage nozzle and low volume nozzle was studied in an experiment with the variety GEB. 24, for controlling gall fly with Folidol E 605-0.08%. Four sprayings were given according to the pest prevalence and random samples were uprooted during the peak period of infestation and all the tillers were examined for pest incidence. The results are given in Table. XXVI below:

TABLE XXVI

Efficacy of Low volume spraying in controlling gall fly

Treatments	Percentage gall fly attacked tillers	Percentage reduction in infestation over check	Yield in pounds per acre	Percentage increase in yield over check	Quantity of spray fluid required to cover one acre (in gallons)
Check	50·76	..	2608·81	..	..
Low volume spraying	42·32	16·63	2795·78	7·12	25
High gallonage spraying	49·22	3·03	2632·09	0·88	79

It may be seen from the above table that:—

(i) spraying the crop with a low volume nozzle was more effective in reducing the incidence of gall fly,

(ii) 25 gallons of spray fluid was sufficient to cover an acre with a low volume spray nozzle.

IV. Control of Stemborers in the cultivators fields

In the main *Kharif* season, the crop was lost in parts of Cuttack District due to sudden floods. About 100 acres in the flood affected area were grown during the *Dalua* season with the varieties MTU.15 and GEB.24 the seeds being donated by the staff of Central Rice Research Institute as a relief measure. Generally, the *dalua* crop suffers heavy damage due to stemborers in Orissa, and therefore large scale field operations were carried out in this area to control stemborer incidence. The method adopted was spraying the crop with insecticides according to moth prevalence as determined by catches at light traps.

Excepting about 5 acres, where the relative efficacy of different insecticides was studied, the entire area was sprayed with Folidol-E605-0.08.%. In all, three sprayings were done, one in the nursery and two after transplanting which effectively controlled the stemborers resulting in uniformly high yields.

In the experimental plots in the same area, the relative efficacy of three insecticides *viz.*, Folidol-E 605; Basudin and Shell Endrin was studied in variety GEB.24. The three insecticides were supplied free of cost to the flood affected area by Messrs. Chika Ltd., Geigy Insecticides Ltd., and Burmah Shell.

At harvest, 2 per cent of the area was examined for white earheads in random samples of 3′ × 3′. The frequency table for the percentage of white earheads and yield in the different treatments are given below:

TABLE XXVII

Comparative efficacy of insecticides in controlling stemborers

Treatment	Mean No. of ear-heads per plant	Mean percentage of white earheads	Percentage reduction of white earheads over check	Yield in lb. per acre	Percentage of increase in yield over check
Check	6·67	7·29	..	1694·24	..
Folidol—0.08% . . .	5·99	4·82	33·87	1953·28	15·29
Basudin—0.03% . . .	6·76	5·56	22·72	1831·36	8·09
Endrin—0.04% . . .	7·03	4·53	37·85	2230·88	31·67

It might be seen from the above table that there were differences in the mean percentage of white earheads, the lowest being in the treatment with Endrin. Similar differences were seen in the yield, the highest yield being in treatment with Endrin. The efficacy of the different insecticides was in the following descending order : Endrin. Folidol and Basudin.

V. Influence of manuring on the incidence of pests

(a) *Leaf rollers.—Cnaphalocrocis medinalis* Gn. Visual observations in a manurial experiment conducted by the Agronomy Division, Central Rice Research Institute, indicated differences in the incidence of the leaf roller.

In order to confirm this, detailed observations were taken by counts of rolled and damaged leaves in systematically placed plants in each treatment. The infestation has been estimated by working the percentage of damaged leaves over the total number of leaves in single plants. The results are tabulated below:

TABLE XXVIII

Influence of manuring on the incidence of leaf roller

Top dressing of Ammonium sulphate Nitrogen lb./acre.	Percentage infestation by leaf roller		Yield in lb. per acre	
	Basal dressing of compost in mds. per acre		Basal dressing of compost in mds. per acre	
	C_0	C_{100}	C_0	C_{100}
N_0	10·17	10·99	1,653	2,144
N_{20}	11·88	13·52	2,085	2,374
N_{40}	11·90	17·49	2,296	2,108
N_{60}	14·87	18·00	2,250	1,634
N_{80}	17·68	24·24	1,956	1,338

It might be seen from the above table that the relation between level of N. and infestation by leaf roller was linear. In rice crop, in the monsoon, the yield response to nitrogen in the form of ammonium sulphate is observed only up to 40 lb. N/acre beyond which any higher level of nitrogen depresses the yield. In the treatment where 80 lb. N/acre was given, the infestation by leaf roller was the highest and yield the lowest. But this low yield was to be expected when 80 lb. N/acre was applied to the crop and the exact loss caused by leaf rollers could not be estimated.

(b) *Stemborers.*—An investigation was undertaken with variety Ptb. 10 to study the effect of heavy manuring (both nitrogenous and phosphatic) as advocated in Japanese method of paddy cultivation, on the stemborer incidence. The treatments and the relevant data are given in table XXIX below.

The first count of attacked and healthy tillers and the number of egg masses was done 30 days after planting. At the time of harvest, counts of white ear-heads and total number of effective earheads were taken by adopting suitable sampling technique.

TABLE XXIX

Influence of manuring on the incidence of stemborers

Treatments	No. of egg masses	Mean number of tillers per plant	Percentage borer attacked tillers (Angular values)	Mean No. of effective earheads per plant	Percentage white earheads (Angular values)	Yield in pounds per acre	Percentage over check
T_1 Check	14	6·36	27·702	5·73	12·99	749·59	100·00
T_2 Japanese method.							
Basal dose—							
(before transplanting).							
Green leaves providing 30 N/A.							
Compost providing 25 N/A.							
Ammonium sulphate providing 20 N/A.							
Superphosphate providing 36 P_2O_5 /A.							
Second dose—							
(one month after transplanting).							
Ammonium sulphate providing 20 N/A.	21	7·92	15·652	6·59	18·91	1214·04	161·9

TABLE XXIX—*contd.*

Treatment	No. of egg masses	Mean number of tillers per plant	Percentage borer attacked tillers (Angular value)	Mean No. of effective earheads per plant	Percentage white earheads (Angular values)	Yield in pounds per acre	Percentage over check
T_3 *Basal dose* — (before transplanting). Ammonium sulphate providing 95 N/A. Superphosphate providing 36 P_2O_5 /A.	53	13·02	25·275	7·32	22·38	1126·50	150·28
T_4 *Basal dose* — (before transplanting). Ammonium sulphate providing 95 N/A.	27	12·14	24·252	7·67	18·96	1038·02	138·48
T_5 *Basal dose*— (before transplanting). Ammonium sulphate providing 75 N/A. *Second dose*— (one month after transplanting). Ammonium sulphate providing 20 N/A.	20	11·76	20·445	7·06	20·87	1030·64	137·49
T_6 *Basal dose*— (before transplanting). Superphosphate providing 36 P_2O_5/A.	19	6·07	26·600	5·37	11·40	777·78	103·76
C.D. (0·05)			5.095		4.151	243.61	

It might be observed from the table that greater number of egg masses were found in the manured treatments. The percentage of borer attacked tillers was more in check and phosphate treated plots than in the plots receiving Nitrogen. The results of harvest count revealed that the percentage of white earheads was significantly more in nitrogen treated plots than in those not receiving nitrogen. Although the percentage of white earheads was more in the treated plots, T2, T3, T4 and T5, the number of effective earheads per plant which finally contributed to yield was also more resulting in increased yields in these treatments.

Analysis of yield data showed that the N treated plots T2, T3, T4 and T5 recorded significantly higher yield than T1 and T6 . The response in yield due to phosphate was negligible.

The application of nitrogen gave good yield response although the borer incidence as judged by white earheads was more. This may be due to the fact that the mean number of effective tillers per plant was more in Nitrogen treated plots.

VI. Occurrence and control of other field pests

Leaf hoppers were found infesting the crop during August and September, in plots where water remained stagnant. Thrips infested nursery and newly planted crop in July and August. These pests were effectively controlled by spraying Folidol-0.08% or Endrin-0.04%. The roots of plants grown in pots were infested in some cases by the root aphids which were controlled by spraying with Folidol 0.08% on the plants and soil.

B. Pests of Stored Grain

Efficacy of prefabricated Aluminium Bin for bulk storage of paddy.—At the instance of the Indian Standards Institution an experiment has been in progress for the Second year to test the suitability of the Aluminium bin for bulk storage of paddy. The Aluminium bin could be put up any where in the field as it is claimed to afford protection against rain and rodents. Its efficacy is being compared with the cultivators wooden bin and the experiment is still in progress.

MYCOLOGY

I. Study and estimation of resistance to diseases, particularly Blast and Helminthosporiose in the collection under Genetic Stocks

The reaction of the types in the Genetic Stock maintained in the Institute to the diseases commonly occurring at Cuttack, was studied. Observations on disease incidence were made on all the types in the seedling stage, but observations in the adult stage were confined to early varieties in the collection. In the seedling stage, 36 types were susceptible to blast and 31 to Helminthosporiose. In the adult stage, 34 of the early types were found susceptible to blast and 11 to Helminthosporiose.

The reaction of the early and medium duration types in the F.A.O. World Genetic Stock to these diseases was also studied. Nine types were found susceptible to blast and 11 to Helminthosporiose in the seedling stage, while in the post-transplanting stage, 14 were found susceptible to blast and only 1 type to Helminthosporiose.

II. Helminthosporium disease

(*a*) *Tests of resistance of selected varieties under natural and artificial infection.*—The performance of six varieties, Ch. 13, Ch. 45, T. 141, Co. 20, T. 498-2A and Bam. 10, found resistant to moderately resistant for the last three years was tested under artificial infection in the field. The performance of the varieties was in conformity with that of previous years.

(*b*) *Co-ordinated trial of selected resistant varieties in different States in India.*—Five of the resistant varieties (Ch. 13, Ch. 45, T. 141, T. 498-2A and Bam. 10) were tested in the 41 centres distributed in the States of Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, Assam, Tripura, Manipur, Orissa, Andhra, Madras, Madhya Pradesh, Hyderabad, Mysore, Travancore-Cochin, Coorg and Bombay. The test was carried out in collaboration with the State Departments of Agriculture. Along with these five varieties, a susceptible standard strain, *Benibhog*, was included in the tests. Observations on disease incidence were recorded on samples received from different centres at three stages, *viz.*, seedling stage, post-transplanting stage (one month after transplanting) and pre-harvest stage.

The disease did not appear in 8 of the centres. The varieties Ch. 13, Ch. 45, T. 141 and Bam. 10 behaved as resistant to moderate resistant in the remaining centres except as follows :—

Ch. 13:— Susceptible at Mangalore (Madras).

Ch. 45:— Moderately susceptible at Samalkot (Andhra) and Pattambi (Madras).

The reason for the deviation in performance of these varieties at the above centres will be investigated.

(*c*) *Artificial infection tests on early types in genetic stock for selection of resistant types.*—There are 490 short duration types (110 days) in the genetic stock. Of these, 172 have already been tested for their resistance to the disease in tests carried out between 1949-1953.

From 1954, the remaining 318 short duration types available in the Genetic Stock were taken up for testing. During 1954-55 season, 150 varieties were tested and 104 were found susceptible and rejected. During the current year, 196 varieties including 46 found resistant in the last season were tested and 68 varieties were found susceptible. Out of the 318 early duration types, 172 have thus been found susceptible in the two seasons' tests. The remaining 146 varieties are being carried forward for further tests.

II. Blast disease

(*a*) *Tests of resistance of selected varieties under natural infection in field experiments.*—Fourteen varieties selected as resistant to moderately resistant last year and 14 additional varieties, including two resistant varieties received from Florida, U.S.A. (Florida Smooth Zenith and Florida 8970), and the variety, Bom. 24, found resistant in Bombay, were tested in a field experiment under natural infection in field. The seedbeds were manured with ammonium sulphate at 20 lb. N per acre about a fortnight after sowing and observations on blast incidence in seedbeds were taken just before planting. In the field, each of the varieties was planted in five 20 ft. long rows and flanked on either side by two rows of a very susceptible variety, Co. 13. There were two replications. Ammonium sulphate at 60 lb. N per acre was applied about a month after transplanting. Observations on neck infection were taken shortly before harvest.

The 14 varieties selected as resistant to moderately resistant last year continued to remain the same at all stages, except the varieties, Mtu. 5, S. 624, and Akp. 9, which showed a susceptible reaction in the seedling stage

only. Amongst the additional 14 varieties, four including Flordia Smooth Zenith showed susceptible reaction in seedbeds but were moderately resistant to neck infection. Bom. 24 behaved as resistant. Florida 8970 was found unsuitable for introduction at Cuttack, but was free from blast.

(*b*) *Co-ordinated trial of selected resistant varieties in different States in India.*—Fourteen varieties, BJ. 1, Sm. 8, Sm. 6, S. 67, Mtu. 5, C.P. 6, S. 624, Akp. 8, Akp. 9, Ch. 55, H. 755, Sm. 9, C.P. 9 and Ptb. 10 selected as resistant and moderately resistant to blast and two hybrids, T. 6517 and T. 6522 from Madras were tested in 41 research centres all over India. The test was carried out in collaboration with the different State Departments of Agriculture. Observations were recorded at three stages *viz.*, seedling stage, post-transplanting stage (one month after transplanting) and pre-harvest stage on samples received from different centres.

The disease did not occur in 10 centres. In the rest of the centres where the disease occurred, the varieties, Bj.1, Sm. 8, Sm. 9, S. 67, C.P. 6, C.P. 9, Ch. 55, H. 755 and Akp. 8 remained resistant at all stages. The varieties Ptb. 10, Akp. 9, S. 624 and T. 6522 behaved as moderately susceptible to susceptible in the seedling stage at the following centres *viz.*, Ptb. 10 at Ollukara (Travancore-Cochin), Akp. 9 at Jeypore (Orissa) and Central Rice Research Institute, S. 624 at Lembuchara (Tripura) and T. 6522 at Jeypore (Orissa) and Nagenhally (Mysore). The variety, Sm. 6 was susceptible at the post-transplanting stage at Jeypore (Orissa). The varieties Mtu. 5 and T. 6517 behaved as moderately susceptible to susceptible at the following centres ; Mtu. 5 at Titabar (Assam), Deras (Orissa), Central Rice Research Institute, Bankura (West Bengal) at seedling stage and at Sambalpur (Orissa) at post-planting stage; T. 6517 at Jeypore (Orissa), Ollukara (Travancore-Cochin) at seedling stage, at Nagenhally (Mysore) at all stages and Amberpet (Hyderabad) at harvest stage.

(*c*) *Artificial infection tests on early types in genetic stock for selection of resistant types.*—As in the case of Helminthosporiose, reported earlier, the early duration group of varieties numbering 490, were taken up for isolation of resistant types. Of these, 157 types were found susceptible in tests carried out during 1949-53. Out of the remaining 333 types, 246 were tested in the current year and 21 varieties developed infection.

(*d*) *Breeding resistant varieties.*—This project is being carried out in collaboration with the Botany Division, to evolve high yielding blast resistant types. Co. 25, a late variety, resistant to blast, was crossed with Co. 13, an early, high yielding type, but very susceptible to blast. F2s and F35 were observed for their reaction to blast in the main season and high yielding early to medium duration selections from amongst the resistant cultures were carried forward as F3s and F4s in the second crop season. Further selections were made for yield, duration and resistance to blast. Promising cultures, as per details given in the report of the Botany Division, are being carried forward for the next year.

(*e*) *Control of blast by spraying.*—(i) *Efficiency of different fungicides.*—The treatments consisted of two sprayings each of (1) Bordeaux mixture 5-5-50, (2) Shell Copper Fungicide 0·5%, (3) Fungimar 0·5%, (4) one dusting of Agrosan dust at 25 lb. per acre and (5) control (unsprayed). The layout was a randomised block with one variety, Co. 13 ; there were 8 replications and the area of unit plot was 29 ft. × 9·75 ft. Thirty five days old seedlings

were planted on 13-8-55 and ammonium sulphate at 40 lb. N per acre was applied one month after transplanting. Sprayings were done on 15-9-55 and 12-10-55. Dusting of Agrosan dust was done on 16-9-55. Observations on percentage of neck infection were taken from 4 random samples of 1.5 ft. × 1·5 ft. each per plot. Yield of each plot was noted. The data are presented in Table XXX below:

TABLE XXX

Mean acre yield and percentage of neck infection obtained with different spraying treatments

	Bordeaux Mixture 5-5-50	Shell Copper Fungicide 0.5%	Fungimar 0.5%	Agrosan dust 25lb. per acre	Control (unsprayed)	C.D. (5%)
Yield per acre in lb	1163	1229	1210	1068	968	128·54
Percentage of Neck infection.	3·31	3·07	3·56	5·27	6·67	..
(Angular Values)	(9·92)	(9·44)	(10·43)	(13·08)	(14·47)	(2·91)

The data showed that all the three spray fungicides were associated with significantly lower percentage of neck infection and significantly higher yields than control. There was no difference amongst the spray fungicides in this respect. One dusting of Agrosan dust was not superior to control, as regards yield and percentage of neck infection.

(ii) *Effect of time and number of sprayings of Coppesan* 0·5% *on the blast incidence and yield of rice.*—The treatments consisted of (i) two sprayings, one before and one after flowering, (ii) one spraying before flowering, (iii) one spraying after flowering and (iv) Control (unsprayed). The layout was a randomised block replicated 8 times with unit plot size of 29 ft. × 9·75 ft. There was only one variety, Co. 13. Observations on the percentage of neck infection were taken in the same way as in the previous experiment. Yields of individual plots were noted. The data are presented in Table XXXI below:

TABLE XXXI

Mean acre yield and percentage of neck infection under different treatments

	1 spraying before and 1 spraying after flowering	1 spraying before flowering	1 spraying after flowering	Control (Unsprayed)
	A	B	C	D
Yield per acre in lb	1062	958	961	828
Percentage of neck infection	1·92	4·57	3·27	6·01
(Angular Values)	(7·94)	(12·26)	(10·25)	(14·05)

C.D. (5%) to compare yield of Treatment A with any of the Treatments B,C,D. = 99·58

C.D, (5%) to compare yields among treatments B,C,D. = 114·91

C.D. (5%) to compare percentage of N.I. (Angular values) of treatment A with any of the Treatments B,C,D. = 2·04

C.D. (5%) to compare percentage of N. I. (Angular values) among treatments B,C,D. = 2·36

The data showed that all the three spray treatments were associated with significantly higher yields than control and the Treatment A was superior to both Treatment B and Treatment C, there being no difference between Treatment B and Treatment C. As regards neck infection, Treatment A and Treatment C were associated with a lower percentage of neck infection than control and of these two treatments, the former was significantly superior to the latter. Treatment B was also associated with a lower infection than control, but the difference was not statistically significant.

(iii) *Efficiency of low volume spraying.*—The treatments consisted of (1) two sprayings, one before and one after flowering, with pressure retaining knapsak sprayers using ordinary nozzles : spray fluid used, Coppesan-0.5 per cent at the rate of 100 gallons per acre for each spraying, (2) similar number of sprayings with low volume nozzles at 20 gallons of spray fluid per acre for each spraying and (3) control (unsprayed). There was only one variety, Co. 13. The crop was planted on 10-8-55 and sprayings were given on 14-9-55 and 8-10-55. Observation on neck infection was taken by sampling. Each unit plot, 93 ft. × 11·25 ft., was divided into 3 strata of equal size. Two random sampling units of 2.5 ft. × 2.25 ft. were taken from each stratum, and percentage of neck infection was noted. Yields of plots were recorded. The data are presented in Table XXXII below:

TABLE XXXII

Mean acre yield and percentage of neck infection obtained with normal, and low volume spraying

	Normal spraying	Low volume spraying	Control (Unsprayed)	C.D. (5%)
Yield per acre in lb.	1135	1091	893	170·74
Percentage of neck infection	9·34	6·31	21·64	
(Angular Values)	(17·43)	(14·03)	(26·95)	(5·89)

The data showed that both normal and low volume sprayings gave significantly higher yields and significantly lower percentage of neck infection than control. Low volume spraying was equally effective as normal sprayings in checking blast infection.

(iv) *Injurious effect of copper fungicides.*—In some of the spraying trials of the previous years to control blast, it was observed that the variety, T. 1145 moderately susceptible to blast, was susceptible to injury to copper sprays inasmuch as spraying 4 times with copper sprays actually depressed the yield to a lower level than control. A trial was therefore conducted in the year

under report with 16 varieties of different durations and belonging to the different susceptibility groups, to have an idea of the extent of copper injury, so far as yield is concerned. There were 3 treatments, *i.e.*, (1) 2 normal sprayings at 100 gallons per acre each, (ii) 2 low volume sprayings at 20 gallons per acre each and (iii) control (unsprayed).

There was very little disease during the season and results were not statistically significant. Nevertheless, the trend of the data clearly indicated that (1) in the case of susceptible varieties both normal spraying and low volume spraying increased the yield (2) in the case of resistant and also moderately susceptible varieties, both normal spraying as well as low volume spraying actually depressed the yield as compared to control and this depression was more marked in the case of normal spraying. This will be followed up by further trials.

IV. Seed treatment with fungicides

(a) The seed treatment experiment with four fungicides, *i.e.*, Agrosan GN, Special Agrosan of low volatility, Fernasan A and YF. 2776 was repeated for the 3rd time during the main season to control Helminthosporium disease.

None of the treatments reduced the incidence of Helminthosporium disease, as compared to control.

(b) An experiment was conducted in the second crop season (January—April) with 11 fungicides, Agrosan GN, Special Agrosan, Fernasan A, YF. 2776, Yellow Cuprocide, Landisan, Harvesan, Abavit B, Ceresan, Fungi Copper and Copper Sandoz. There were two varieties, Ch. 45 and Benibhog, resistant and susceptible to Helminthosporium disease, respectively. Seeds were treated with the fungicides at the rate of 1:400 parts of seed by weight and sown directly by broadcast. The layout was a split plot with varieties as the main split and fungicides as second split in 4 replications. The unit plot size was 14.9 ft. × 9.5 ft.

Observations were taken on the germination and number of plants affected with leaf spots of Helminthosporium disease in five sampling units, 6 in. square each, per plot, about 3 weeks after sowing. Yields of individual plots were recorded. The data on the total number of germinated seeds in five sampling units per plot (average of 4 replications) are presented in Table XXXIII below :

TABLE XXXIII

Average number of germinated seeds (total of 5 samples) per treatment (Average of 4 replications)

Treatments	Varieties		Mean
	Benibhog	Ch. 45	
Agrosan GN	41·2	30·2	35·7
Agrosan Special	58·5	45·0	51·7
Fernasan A	50·7	36·2	43·4
YF. 2776	41·2	28·0	34·6

TABLE XXXIII—*contd.*

Treatments	Varieties		
	Benibhog	Ch. 45	Mean
Cuprocide Yellow.	52·5	40·5	46·5
Landisan	52·0	41·7	46·8
Harvesan	35·5	30·0	32·7
Abavit B.	42·5	36·5	39·5
Ceresan	48·5	39·5	44·0
Fungicopper-Geigy	50·5	43·2	46·8
Copper Sandoz.	55·0	41·2	48·1
Control (Untreated)	40·0	26·0	33·0
Mean	47·3	36·5	41·9
C.D. (5%) to compare varietal means			12·900
C.D. (5%) to compare treatment means			11·056
C.D. (5%) to compare treatment means within a variety			15·639
C.D. (5%) to compare varietal means within a treatment			19·263

Analysis of the data showed that the fungicides, Agrosan Special, Yellow Cuprocide, Landisan, Fungi Copper and Copper Sandoz were associated with significantly higher germination of seeds than control, and of these Agrosan Special appeared to be the best. There was no significant difference between the fungicides and control, as regards disease incidence.

STATISTICS

In addition to helping the various research divisions in the design of experiments and interpretation of results, the following investigations were carried out.

1. *Estimation of yield by sampling for the ratio of grain weight to total produce.*— Investigations were made to study the comparative efficiency of direct sampling and the sampling for the ratio of grain to total produce for estimating yield. The sampling units adopted were 3×3 feet, $4\frac{1}{2} \times 4\frac{1}{2}$ feet and 6×6 feet. It was found that sampling variance for the ratio method was less than that for the direct estimate in case of all the three sampling units. Stratification of the plots, however, did not give any appreciable increase in accuracy.

The analysis of variance of actual and estimated yield by both the methods were carried out and the results are presented in Table XXXIV below:

TABLE XXXIV

Actual and estimated mean yield in lb. per plot (15 ft. × 36 ft.) *and C. V.*

	Estimated by direct method of sampling			Estimated by ratio method of sampling			Actual yield
	3′×3′	4½′×4½′	6′×6′	3′×3′	4½′×4½′	6′×6′	
Mean yield in lb. per plot .	29·02	28·55	27·71	29·28	29·33	29·08	27·34
Co-efficient of variability .	8·37	6·83	8·44	5·77	5·05	4·33	4·86

It may be seen from the table that C.V. for the estimated yield of grain by ratio method is less than that for the direct estimate and is nearly same as that of actual yield. Further investigations are in progress.

2. *Sampling for estimation of blast incidence.*—The data from five field experiments in which sampling observations were taken on blast incidence were utilized to find out the efficiency of sampling and to determine the number of samples per plot required to estimate the mean incidence at given level of accuracy. The sampling units adopted in these experiments were $2 \times 1 \cdot 5$ feet, $2 \cdot 3 \times 1 \cdot 5$ feet and 2×2 feet and the plot size ranged from 150 to 400 sq. ft. Analysis of data showed that in all the experiments sampling variances were higher than the true plot variances. The amount of information obtained ranged from 56 to 89 per cent with sampling fractions ranging from 8 to 14 per cent. Stratification of plots was found to add only very little to the efficiency of sampling. With the plot size adopted in the above experiments ranging from 150-400 sq. ft. and with 6 to 10 replications, it was found that 2 to 5 samples of 2×2 feet were sufficient to estimate mean incidence due to neck infection with 6 to 8 per cent standard error.

3. *Border effect.*—The study of the effect of margin on the plot yields was continued. The relevant data were collected from a long duration varietal trial consisting of 18 varieties planted with 9×9 in. spacing. Harvesting of each plot was done ring by ring upto the 3rd ring only and the rest of the rings were clubbed together as one unit for yield purpose.

It was observed that only the outermost ring yielded 38 to 95 per cent more per unit area than the central portion and there was no significant difference between the yields of subsequent rings. It was also noticed that when margin (*i.e.*, outermost ring) is not excluded, the general mean is comparatively higher than when the margin is removed. These are in conformity with the last year's findings. The mean yields of the different rings in lb. per acre for the long duration varietal trial mentioned above are presented below along with the data obtained during last year in a short duration varietal trial and manurial trial for purposes of comparison.

TABLE XXXV

Average yield in lb. per acre for different rings averaged over the treatments and varieties

Experiment	Outermost ring	Second ring	Third ring	Fourth ring	Fifth ring	Central portion	C.D. (·05)
Varietal (Long duration) 9″×9″ spacing	2891	1914	1794	..	..	1736	183.9
Varietal (Short duration) 6″×6″ spacing.	3370	1975	1792	1711	1691	1648	103.2
Manurial 10″×10″ spacing	5106	3295	3102	3085	3000	3210	295.0

It may be concluded from the above table that although removal of one row all round the experimental plot would be adequate to eliminate the border effect, it may be necessary to exclude two rows where closer spacings are adopted. In general a border of nearly one foot all round the experimental plot may be excluded to avoid the marginal effect on plot yields.

The coefficients of variability for various plot sizes in all the three experiments were worked out with a view to correlate them with plot size. The observed C.Vs. were found to decrease with increased plot sizes and equation of the form $y=ax^{-g}$ was found to fit the data satisfactorily, where x is the size of the plot and y is the corresponding C.V.

4. *Inheritance of quantitative characters.*—For studying quantitative inheritance, statistical analysis of data was undertaken on length, breadth and thickness of grain from parents, F1, F2, F3s obtained by the Botany Division. As regards grain length, the mean values of F1 was below the mid-parent and, therefore grain length did not show heterosis. The means of successively selfed generations showed increasing trend. Further analysis of the data is in progress.

FARM AND MISCELLANEOUS

I. Multiplication of improved strains of paddy

A total quantity of 1812 maunds of seed of the most popular strains of Orissa State was produced during the year for distribution.

II. Maximum Potential Experiment

This is a permanent experiment now in progress for 7 years on the same site to see how far the yields could be pushed up on this block by proper cultivation methods. A green manure crop of *dhaincha* grown *in situ*, giving about 5,000 lb. of green matter was buried and strain, BAM. 9 was planted in the last week of July. The crop established itself well and received ammonium phosphate at the rate of 160 lb. per acre as a basal dressing. The crop was quite normal in its growth and was free from pests and diseases. An average acre yield of 2,553 lb. per acre, was obtained against 3461 lb. of the previous year. Unfavourable weather conditions like floods etc., which prevailed during the critical phases of the crop growth affected the yield.

III. Cultural Trials

(1) *Comparative efficiency of sowing practices.*—In this experiment the following three sowing practices were compared:

(i) Dibble sowing in June under optimum moisture conditions (dry).

(ii) Dibble sowing sprouted seed in puddle in July.

(iii) Transplanting in July.

Two varieties, T. 141 and T. 1242 were tried.

The yield obtained under dibble sowing in July of sprouted seed was as good as that obtained under transplanting in the case of T. 141, while in the case of T. 1242 the transplanted crop gave an increased yield of about

14 per cent over that dibbled in puddle. The dibble sown crop (dry) of T. 141 and T. 1242 in June gave much less than the transplanted crop. The yield data are given in Table XXXVI below:

TABLE XXXVI

Table showing the grain yield in lb. obtained with different sowing practices

Treatments	Transplanting	Dibble sown dry	Dibble sown in puddle	Mean
1. Variety T. 141	2363	1654	2478	2165
2. Variety T. 1242	2196	1831	1911	1846
Mean	2280	1743	2195	..

1. C.D. (·05) to compare variety means	124·5
2. C.D. (·05) to compare treatment means	121·5
3. C.D. (·05) to compare treatment means within a variety	171·8
4. C.D. (·05) to compare variety means within a treatment	187·1

The dibble sown crop gave increased yield of straw, the increase ranging from 7 to 24 per cent as compared with transplanted crop.

(2) *Effect of seedbed practices on yield of crop.*—In this experiment the comparative efficiency of three methods of raising seedlings *viz.*, (i) Japanese method, (ii) dibbling seed in plough furrows in the seed bed, and (iii) the customary practice of broadcast sowing in the seed bed, on the ultimate yield of crop was investigated. There was no difference between the treatments with regard to the ultimate yield of the crop. The results are in conformity with those obtained in the previous two years.

(3) *Effect of ridging on yield of crop.*—In this experiment the effect of ridging of the crop on lodging and yield was investigated. It was seen that though ridging helped to prevent lodging to some extent, there was no significant increase in yield between the ridged and non-ridged plots.

(4) *Lodging in relation to yield of crop.*—In this experiment T. 1242 was grown under well manured conditions and was artificially lodged at preflowering and post-flowering stages. Propped up plants served as control. The results confirmed the findings of the previous year that the crop which was lodged at the time of flowering and preflowering stage suffered the most o ss in yield which amounted to 46 and 38 per cent respectively this year, while

the losses suffered by the crop due to lodging at the dough and ripening stage were lower and amounted to 16 and 9 per cent respectively, of the propped up non-lodged crop. The yield data are given in Table XXXVII below:

TABLE XXXVII

Table showing the effects of lodging on grain yield in lb. per acre
(Variety T. 1242)

Treatments	Lodging at pre-flowering. 15-10-55	Lodging at-pre-flowering 25-10-55	Lodging at pre-flowering 4-11-55	Lodging at post-flowering 14-11-55	Lodging at post-flowering 24 11-55	Control (propping the crop)	C.D. (0·5)
Yield per acre . . .	1567	1354	1637	2108	2282	2513	167·73
% over Control . . .	62·4	53·9	65·1	83·9	90·8	100·0	..

(5) *Trial of intercultural practices.*—An experiment was carried out to determine the effect of three intercultural practices, *viz.*, (1) Japanese weeder, (2) Country plough, (3) hand weeding and (4) Control 'No weeding'.

This experiment was carried on a transplanted crop of T. 1242 in a lowland where water remained to a depth of about two inches till the land was drained for quick and uniform maturity. There was no difference in yield between the different treatments.

(6) *Determining the optimum time of planting for the second crop of rice of the varieties Mtu. 15, and Geb. 24.*—The varieties, Geb. 24 and Mtu. 15, were planted at fortnightly intervals, beginning from the 21st November 1955, to the 16th January, 1956.

"Blast" appeared during the first week of February and affected the crop, the intensity of damage was rather severe in the case of the variety Geb. 24. The maximum yield was obtained in the plantings done in the third week of December.

(7) *Effect of fertilizing the rice crop at the time of flowering on yield.*—An experiment was carried out in the second crop season to assess the additional benefits of fertilizing rice at the commencement of flowering with the variety, Mtu. 15. The control plots received 20 lb. N per acre as basal dose, while the treated plots received an additional quantity of 20 lb. N at flowering as Ammonium sulphate. It was found that fertilizing at flowering resulted in a significantly higher yield of 349 lbs. (15%) over control yield of 2446 lb. per acre.

(8) *GEB. 24 as second crop.*—Geb. 24 was planted on 21-12-55 with 40 days old seedlings, adopting a spacing of 9′ × 3′ with two seedlings per hill. The crop received 20 lb. of Nitrogen as a basal dose and 20 lb. of Nitrogen at flowering in the shape of Ammonium sulphate. The crop flowered in the middle of March and was harvested in the middle of April. An acre yield of 2737 lb. was recorded from an area of 9.5. cents.

IV. Intensive Cultivation Centre

Propaganda, demonstration of improved cultural practices, such as growing green manure, application of fertilizers etc., and distribution of improved seeds were continued in the intensive cultivation centre. The following are the important features of the work done during this year:

(1) 320 maunds of high yielding paddy strains giving 10 to 16 per cent more yield than the farmers' varieties were distributed.

(2) Propaganda and demonstration were carried out, (i) to popularise the practice of sowing paddy mixed with *dhaincha*, the crop of the latter being buried as green manure to the rice crop at the time of *beaushenning* and also to use the economic seed rate of 60-80 lb. per acre against the local seed rate of 100-120 lb. (ii) The practice of dibble sowing and transplanting rice crop was demonstrated to get bigger outturns.

(3) The growing of *dhaincha* plants for seed purposes along the fringe of the field bunds at the time of '*beaushenning*' or transplanting was popularised.

(4) The farmers were educated regarding the need for the maintenance of purity of nucleus seed by actually demonstrating to them in the field the method of 'roguing' the off types at the flowering and ripening periods.

(5) Six comparative (varietal) yield trials with the promising paddy strains were conducted in the cultivators fields. One of the superfine varieties, J. 192 gave an increased yield of 10 per cent over the local variety in the trial.

(6) An area of about 100 acres in the flood affected village of Tarpur about 20 miles from the Institute was planted with a second crop variety of Mtu. 15 and Geb. 24 as mentioned earlier. The crop was sprayed with Folidol to check stemborer attack. An average yield of 30 maunds per acre was obtained over 100 acres, the highest yield recorded being 55 maunds per acre.

(8) Thirty three simple manurial trials were conducted in Tarpur village under the T.C.M. project. The results showed that the application of ammonium sulphate or urea to supply 30 lb. Nitrogen per acre gave an increased yield of about 300 lb. over the control, 'no manure plot'.

TRAINING

1. Post-Graduate Course

Three 2nd year Post-graduate students of the Indian Agricultural Research Institute Associateship Course specialising in rice Agronomy joined the Institute for doing the thesis part of the Course and worked on the following research problems.—

1. The relative efficiency of various nitrogenous fertilizers on the rice crop.
2. Efficiency of selective herbicides for control of weeds in rice crop.
3. Effect of placement and fractional application of sulphate of ammonia to wet land paddy.

II. Training in Mycology and Plant Pathology

1. The Special Officer for "Rai" disease investigation, Kashmir and Jammu, was given training for a period of three months in plant pathological technique with special reference to blast disease of rice and identification of important rice diseases.

2. An Officer from the Orissa State Agricultural Department was given special training in Mycological laboratory technique for a period of one month.

3. Two Post-graduate students of Utkal University carried out studies on the fungicidal efficiency of a series of mercurated thiazoles and other compounds synthesised at the Chemistry Department of Ravenshaw College, under the guidance of Mycologist. The work formed a part of their D. Phil. thesis.

4. The Assistant Mycologist submitted a thesis for the D. Phil. degree of Calcutta University.

III. Cultural Scholar from Japan

Shri A. Tanaka, Scholar from Japan under the Cultural Scholarship Scheme of the Government of India worked in the division of Agricultural Chemistry on the problem of rice plant nutrition with particular reference to nitrogen requirement.

IV. "International Training Centre on Rice Breeding"

An International Training Centre for Rice Breeding was conducted at the Institute in collaboration with the F.A.O. of United Nations. The training course which lasted for three months (1st September 1955—30th November 1955) was attended by twenty trainees from 13 other countries including India, *viz.*, Borneo, Burma, Ceylon, Egypt, India, Indonesia, Iran, Japan, Laos, Pakistan, Philippines, Thailand and Viet-Nam.

V. Extension staff and Trainees

Training in modern intensive cultivation methods was given to fifty five trainees of the Basic Agricultural School of Balasore District, Orissa, and to 100 students of the Basic Agricultural School of Dhenkanal District, Orissa and to 36 students of the Extension Training Centre, Bhubaneswar.

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PROGRAMME OF WORK FOR 1956-57

AGRONOMY DIVISION

I. Study of yield performance of different duration varieties.

II. Trial of varieties suitable for late *aman* planting and for double cropping.

III. To determine the suitability of various crops for growing in rotation with rice.

IV. Study of the relative efficiency of various nitrogenous fertilizers.

V. Determination of the optimum dose, time and method of application of different nitrogenous fertilizers and their residual and cumulative effect on the soil fertility.

VI. Study of the response of rice to N, P & K nutrients and organic matter.

VII. Study of the efficiency of various herbicides for control of weeds in the rice fields and to determine the optimum dosage and time of their application.

STATISTICS DIVISION

I. Study of marginal effect with different spacings and varieties on plot yield.

II. Continuation of sampling studies for estimation of yield by the ratio of grain to total produce.

III. Study of trends and correlation between different characters in successive generations.

IV. Developmental studies of plant characters.

BOTANY DIVISION

I. Maintenance and study of Genetic Stocks, including the F. A. O. World Catalogue.

II. Maintenance of nucleus seed of promising strains.

III. Improving yield by :—

(i) Introduction.

(ii) Selection—Secondary selection in Chinese varieties.

(iii) Hybridization :

(a) Between *japonica-indica* rices.

(b) Within *indica* group of rices.

IV. Breeding for high yielding *Basmati* strains.

V. Breeding for up land conditions.

VI. Breeding for disease resistance. (Blast & Helminthosporiose).

VII. Breeding for non-lodging habit.

VIII. Breeding for better quality and high yielding strains.

IX. Genetics :—

Linkage groups.

Liguleless, auricleless, juncturaless mutant.

Non-lodging character.

Dwarf mutant.

Anthocyanin pigmentation.

X. Cytology and Cytogenetics :—

(a) Study of the Origin of the cultivated rice.

(b) Study of the formation of sub-species of *O. sativa viz., indica, joponica, javanica.*

(c) Field experiments on tetraploids.

(d) Development of cytological technique for the study of small chromosomes in Oryza.

(e) Interspecies hybridization and use of embryoculture in raising hybrid embryos.

XI. Jeypore Botanical Survey Scheme :—

(1) Study of the cultures raised from the collections.

(2) Exploration and collection of material in :—

(a) Nowrangpur taluk, (b) Adjoining areas in Baster district of Madhya Pradesh and (c) Koraput taluk.

(3) Examination of material collected for grain characters.

CHEMISTRY DIVISION

I. Study of water logged soil-nutrient changes and fertilizer losses.

II. Methods of soil sampling and Analysis of water logged rice soils.

III. Investigations on nutrient assimilation and plant growth in relation to yield of crop.

ENTOMOLOGY DIVISION

I. Study of reactions of genetic stocks to pests in general and leaf hoppers, gall fly and stem borers in particular (*Sarad* and *Dalua* varieties).

II. Studies on insect resistance in rice plant with special reference to gall fly and stem borers.

III. Efficacy of different methods of application of insecticides in the control of rice pests.

IV. Effect of gall fly and stem borer incidence on tillering.

V. Estimation of loss in yield due to gall fly and stem borers.

VI. Insecticidal trials to control pests of rice.

VII. Incidence of pests in relation to manuring.

VIII. Studies on seasonal abundance of pests with a view to forecasting out-break of major pests.

IX. Studies on alternate hosts of major pests of rice.

X. Studies on gall formation in rice.

XI. Collection of indigenous parasites of the more important pests of Rice with a view to utilising them for biological control of pests of Rice.

XII. Efficacy of Aluminium bin for bulk storage of paddy.

MYCOLOGY DIVISION

I. Study and estimation of resistance to disease in field of the Collection of types under genetic stocks.

II. *Helminthosporium disease* :—

(a) Co-ordinated trial of selected resistant varieties in different States in India.

(b) Artificial infection tests on early types in genetic stocks for selection of resistant types.

(c) Breeding resistant varieties.

(d) Study of the nature of disease resistance of rice varieties.

III. *Blast Disease* :—

(a) Co-ordinated trial of selected resistant varieties in different States in India.

(b) International Co-operative Trial on breeding for blast resistance.

(c) Artificial infection tests on early types in genetic stocks for selection of resistant types.

(d) Breeding resistant varieties.

(e) Control of Blast by spraying.

(f) Estimation of loss in yield due to blast.

FARM DIVISION

I. Multiplication of improved paddy strains.

II. Determination of the merits of sowing practices, namely, (1) dibbling, (2) Broadcast sowing of sprouted seeds in puddle, and (3) transplanting under optimum conditions.

III. Maximisation of crop yield under the improved methods of cultivation.

IV. Enlargement of the extension work in the Intensive Cultivation Centre.

STAFF (1955–56)

Director. . . . . N. Parthasarathy, Ph.D. (Lond.), F.N.I., upto 31-1-1956.

R. L. M. Ghose, M.Sc., F.A.Sc., from 1-2-1956.

AGRONOMY DIVISION

Agronomist . . . . . Moti V. Vachhani, B.Ag., Ph.D.

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Research Assistant	K. A. Rahim Khan, B.Sc. (Agri.), Assoc. I.A.R.I.
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I. C. A. R. Scheme for further research on Green manuring crops for paddy

Research Assistant	K. S. Murthy, M.Sc.

I. C. A. R. Scheme for Survey and Collection of Breeding Materials from Jeypore Tract of Orissa State

Assistant Botanist	S. Govindaswamy, M.Sc., Ph.D.
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